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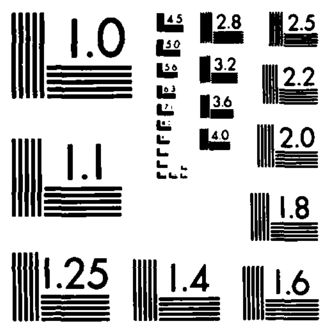

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THE UNIVERSITY OF OKLAHOMA

WORKLOAD DEMAND AND CNS DEPRESSANT
STRESSOR EFFECTS ON SPATIAL
ORIENTATION INFORMATION PROCESSING

Robert E. Schlegel

Final Scientific Report
AFOSR-83-0181

School of Industrial Engineering
Norman, Oklahoma 73019

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An important element of piloting high-performance jet aircraft is the human ability to perform spatial orientation information processing, particularly when it involves the use of video display instrumentation. Spatial disorientation has consistently been the cause of numerous accidents throughout the history of flight. A study was conducted to further evaluate the Manikin Task, a complex reaction time task previously developed by the RAF as a test of spatial orientation. The objectives of the study were to (1) thoroughly evaluate the training characteristics of the task including variation in

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performance related to individual stimuli characteristics, (2) determine the task's speed vs. accuracy tradeoff characteristics, and (3) assess performance on the task under the influence of ethyl alcohol.

Response times and accuracy were measured on five subjects under various conditions over a five-week period. Analysis of the data indicated a substantial dependence of response times on certain stimuli characteristics. In addition, there was a definite decline in accuracy corresponding to a forced decrease in response time. However, the relationship could not be adequately represented by the proposed speed-accuracy tradeoff functions. The effect of alcohol was evidenced primarily by a change in the slope of the speed-accuracy tradeoff relationship.

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SUMMARY

A study was conducted to further evaluate the Manikin Task, a complex reaction time task previously developed by the RAF as a test of spatial orientation. The objectives of the study were to (1) thoroughly evaluate the training characteristics of the task including variation in performance related to individual stimuli characteristics, (2) determine the task's speed vs. accuracy tradeoff characteristics, and (3) assess performance on the task under the influence of ethyl alcohol.

Response times and accuracy were measured on five subjects under various conditions over a five-week period. Analysis of the data indicated a substantial dependence of response time on specific manikin orientations. In addition, there was a definite decline in accuracy corresponding to a forced decrease in response time. However, the relationship could not be adequately represented by the proposed speed-accuracy tradeoff functions. The effect of alcohol was evidenced primarily by a downward shift on the accuracy axis of the speed-accuracy tradeoff relationship.

ACKNOWLEDGEMENTS

This research was sponsored by the Air Force Office of Scientific Research/AFSC. It was initiated under contract F49620-82-C-0035 administered by the Southeastern Center for Electrical Engineering Education (SCEEE) and completed under grant AFOSR-83-0181. The author would like to thank the staff of the Crew Performance Branch, Crew Technology Division, USAF School of Aerospace Medicine and in particular Drs. William F. Storm, John F. Courtright and Loren G. Myhre. Appreciation is extended to the Technical Program Manager for the grant, Dr. Alfred R. Fregly of the Life Sciences Directorate at AFOSR. The author is indebted to Sundararajan Venkataraman for his major contributions to the data analysis and to David W. Patterson for his assistance in preparation of the final report.

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1.0 INTRODUCTION

The development of safe, efficient, cost effective systems for piloting high-performance jet aircraft requires a thorough understanding of the complex psychomotor skills, information processing and high-speed decision making components involved. Determination of the underlying mechanisms of these processes during both normal and high-stress situations is an essential part of the development of advanced military systems.

One isolatable element of the information processing component involves the pilot's ability to perform spatial orientation activities. It is vitally important that the pilot and other crew members maintain their ability to differentiate right vs. left and up vs. down based on available visual cues under severe conditions of disorientation and exposure to various types of stressors.

Spatial disorientation has consistently been cited as the cause of numerous accidents throughout the history of flight. Kirkham et al. (1978) reported that during a recent six-year period, spatial disorientation was the third-highest cause of fatal accidents in small, fixed-wing aircraft. In addition, approximately 15% of fatal accidents in military aircraft flown by highly trained and instrument-rated pilots are caused by spatial disorientation.

To attack this problem, three general directions of research activity have been defined as follows:

1. investigate potential theories to describe the underlying mechanisms associated with spatial information processing;

2. identify and/or develop appropriate means of measuring an individual's ability to perform spatial processing;

3. evaluate the sensitivity of the process and of the measuring instrument to various stressing agents.

Of particular interest in the last category are the effects of varying workload demands and certain chemical defense drugs which act as central nervous system (CNS) depressants. This topic served as the primary area of investigation in the study reported here.

This final report documents the evaluation of a specific test of spatial orientation or mental rotation known as the Manikin Task. The objectives of the study were established as follows:

1. thoroughly evaluate the training characteristics of the task including variation in performance related to individual stimuli characteristics;

2. determine the speed vs. accuracy tradeoff characteristics of the task;

3. assess performance on the task under the influence of ethyl alcohol.

The study was initiated in conjunction with the author's participation in a USAF-SCEEE Summer Faculty Research Program and completed under the current grant to the School of Industrial Engineering, University of Oklahoma. Data analysis was performed using the Statistical Analysis System (SAS) implemented on the IBM 3081 of University Computing Services at the University of Oklahoma.

2.0 BACKGROUND

2.1 Manikin Task

The Manikin Task was originally conceived by Benson and Gedye (1963) at the Royal Air Force (RAF) Institute of Aviation Medicine (IAM), Farnborough, U.K., and was employed as a complex reaction time test to measure the spatial processing ability of pilots. The task is a visual performance activity in which a sequence of human figures (manikins) in various orientations is presented on a CRT screen. The orientation categories consist of (1) back-erect [BE], (2) back-inverted [BI], (3) front-erect [FE] and (4) front-inverted [FI].

For each presentation, the subject is required to identify in which hand (left or right) the manikin holds a particular target (circle or square) identical to one presented below the figure. This requires the subject to execute some form of mental rotation of the figure about one or more axes in order to discriminate the right side from the left.

The original task used 35mm slides to present the sequence. Improved versions have been developed using computer generated CRT displays. A sophisticated version which provides for manipulation of several task parameters was implemented on a PDP 11/34 computer located at the USAF School of Aerospace Medicine.

A comprehensive assessment of the utility of the Manikin Task was initiated by researchers at USAFSAM. Through a series of experiments it has been shown that the task satisfies many of the criteria necessary to be considered a useful laboratory measure. In particular:

1. subjects can learn the task and acquire plateau performance within 4 to 10 training sessions, each of 30 minutes duration;

2. the rate of acquisition of plateau performance is essentially independent of the training schedule, occupational level and age of the subject;

3. the task has a high level of differential stability, i.e., individual performance remains essentially constant over time (Reader et al., 1981).

In addition, the task has been shown to be sensitive to mild hypoxia (Benel and Storm, 1981) but insensitive to changes in head temperature under hyperthermic conditions (Nunneley, Reader, and Maldonado, 1982).

With respect to the various manikin views, Reader et al. (1981) found significant response differences associated with the orientation category and the side of correct response ($p < 0.001$). In increasing order of difficulty, the orientations were back-erect, front-erect, front-inverted and back-inverted. Also, the right-side responses were approximately 25 msec faster than the left. No differences due to target shape were observed.

Thus, an initial data base had been developed which demonstrated the potential value of the Manikin Task. A logical extension of the assessment effort was an evaluation of the task's sensitivity to other human stressors.

Two general categories of stressors were investigated in terms of their effects on performance of the task: (1) workload demand stress created by imposing relatively short deadlines for subject responses and (2) a CNS depressant, specifically alcohol. It was also believed that the knowledge gained from collecting additional data on the task would lead to recommendations for improved task administration methodologies. These would include various procedural aspects, stimulus presentation rates and certain adaptive test variations.

2.2 Speed-Accuracy Tradeoffs

With respect to many psychomotor tasks, it has been proposed that the inconsistency of previous results concerning the effects of alcohol on reaction time (RT) may be related to possible tradeoffs between speed and accuracy (Jennings et al., 1976). In the majority of information processing studies in which RT is used as the primary criterion, subjects are usually encouraged to respond "as rapidly and accurately as possible." The RT and error rate values obtained thus represent an unpredictable compromise between the incompatible demands for maximum accuracy and minimum RT. This tradeoff may be represented by the function illustrated in Figure 1.

The particular compromise between speed and accuracy that is adopted for any given experimental trial is a function of several variables including the actual experimental conditions under investigation. It is therefore difficult to derive any valid conclusions in situations where the change in subject criteria is not identified and measured.

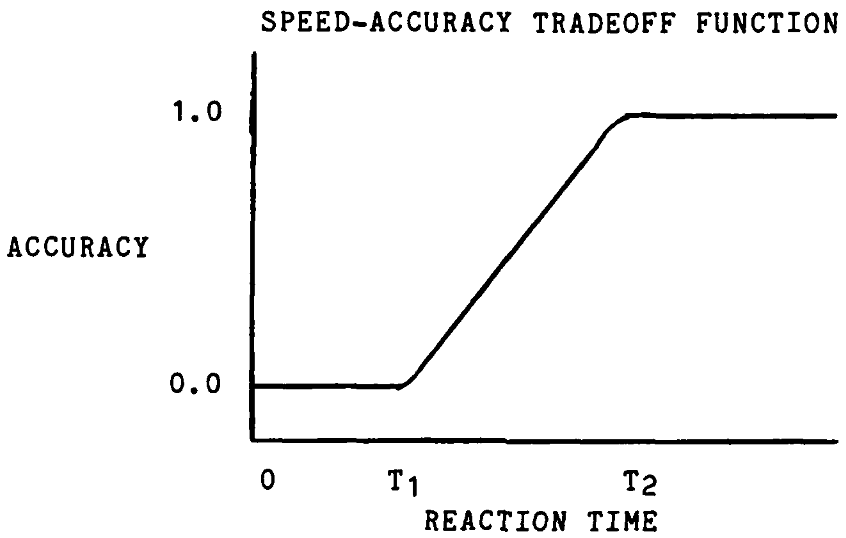

Figure 1. Idealized Speed-Accuracy Tradeoff Function (Wood and Jennings, 1976).

Although perfect accuracy is rarely achieved in RT studies, relatively high levels can often be attained. Reported data confirm that accuracies greater than 90% are common (Wood and Jennings, 1976). However, these accuracy levels may be unrealistic in view of the fact that task demands often do not allow sufficient time for a highly accurate response. Also, an examination of the tradeoff function in Figure 1 reveals that very small changes in error rate at high levels of accuracy are associated with large changes in RT. Again, this makes it difficult to determine if significant differences in measured reaction time are due to experimental conditions or merely related to slight shifts in the subject's internal criterion point.

Several researchers (Lappin and Disch, 1972 a,b; Pachella, 1974; Pew, 1970) have suggested that the solution to these problems is to utilize the complete tradeoff function as a measure of information processing performance in which changes in bias for speed and accuracy can be directly assessed. This approach allows one to distinguish a shift in the subject's speed-accuracy criteria from a possibly more significant change in processing efficency independent of a shift in criteria. Processing efficiency differences can be easily identified by changes in either the slope or RT intercept of the tradeoff function.

This procedure has been employed in at least two studies evaluating the effects of alcohol on speed-accuracy trade-offs. In an experiment by Jennings et al. (1976), five levels of alcohol were examined ranging from 0.00 to 1.33 ml/kg of body weight. Increasing doses of alcohol produced a progressive decrease in the slope parameter of linear equations fit to the speed-accuracy data, but did not significantly alter the intercepts of the functions with the RT axis. Thus, alcohol reduced performance efficiency by decreasing the rate of growth of accuracy per unit change in response time. Similar results were obtained in a study by Rundell and Williams (1979) who examined alcohol levels from 0.0 to 1.0 g/kg of body weight.

In both studies, deadline conditions were imposed to force subjects to respond within various time limits. The time limits were selected to provide accuracies ranging from chance levels to near perfection. These procedures have the effect of altering the workload demand such that the shorter time limits create extreme time-stressed conditions.

A similar approach was employed in this study to generate the data for computing speed-accuracy tradeoff functions for the Manikin Task. Data was collected for both baseline and alcohol conditions.

3.0 EXPERIMENTAL METHODOLOGY

3.1 Subjects

Five male subjects, ages 18 to 49, participated in the study. All subjects were right-handed with normal (20/20 corrected) vision and were light to moderate social drinkers averaging 4 to 8 drinks (mixed drinks, beers, or glasses of wine) per week. Each subject performed the task under both baseline and alcohol conditions. The experimental protocol was approved by the Human Use Committee and the voluntary informed consent of the subjects was obtained in accordance with AFR 169-3.

3.2 Task

Each subject was instructed to observe a 25cm CRT display (Digital Equipment Corporation Model VR17LC) located 1 meter in front of him (approximately 15° visual angle). For each stimulus presentation, the subject was to mentally reorient the manikin and decide in which hand the manikin held a shape identical to the target shape displayed at the bottom of the screen. A response was registered by pressing either the right or left button on a subject panel, always using the same finger of the right hand. Response time was measured from the initial presentation of the stimulus until the subject's response and was recorded along with the accuracy of the response.

3.3 Procedure

The investigation consisted of initial training sessions, testing sessions to derive the speed-accuracy tradeoff function under baseline conditions and testing sessions employing alcohol.

3.3.1 Training

In the initial training sessions, each manikin remained on the screen for 2 seconds with a 1-second pause between presentations. A series of 96 manikins was presented in a random sequence followed by 2 minutes of rest. Four of these periods were grouped to form a single testing session or trial lasting approximately 25 minutes. All subjects participated in a minimum of 7 training sessions. Previous results (Reader et al., 1981) had shown that an average of 6 sessions are needed to achieve stable performance on the task. The criteria for terminating training required a deviation of no more than ± 5% of the mean reaction time for the previous 2 sessions.

3.3.2 Baseline

Following training, the amount of time that the manikin remained on the screen was reduced to levels ranging from 400 to 100 msec. The pause between presentations was increased accordingly to maintain a 2-second interval between the onset of successive presentations. All other variables remained the same as during the training sessions. Subjects were instructed to respond "at or before the instant the manikin leaves the screen." This provided the deadline conditions essential for measuring subject performance over a wide range of speed and error rates.

3.3.3 Alcohol

Following the baseline condition, a single alcohol dose consisting of 0.50 to 0.75 grams of pure alcohol per kilogram of body weight was administered to each subject. The actual dose depended on the body composition of the individual subject and was the calculated dose required to raise the subject's blood alcohol concentration (BAC) to a level of 0.08%. Subjects were instructed not to consume alcoholic beverages on the evening before the alcohol testing trial. Testing sessions were conducted in the morning prior to the consumption of any food or drink other than water.

The equivalent volume of 86 proof bourbon was combined with water in the ratio of two parts water to one part alcohol. Subjects were allowed 15 minutes to consume the beverage. Following consumption, blood alcohol levels were indirectly measured according to the procedures of Dubowski (1970) and Spector (1971), using an Intoxilyzer, Model 4011 alcohol-in-breath tester manufactured by CMI Incorporated.

Testing was initiated approximately 30 minutes after consumption of the alcohol. To sustain peak BAC levels and thereby circumvent problems associated with differential performance on the ascending and descending limbs of the blood alcohol function, a maintenance dose of 0.05 g/kg of body weight was administered every 20 minutes (Lentz and Rundell, 1976). Following the experimental task, the subject was monitored until his BAC was at or below 0.005% and was then released.

3.3.4 Trial Sequence

For the alcohol evaluation stage of the study, each subject entered the laboratory in the early morning and performed three baseline testing trials, one each under the 1000, 700 and 400 msec deadline conditions. The subject was then weighed and the appropriate dose was calculated. Alcohol was administered and sufficient time elapsed for the subject to attain the desired BAC level. The subject then performed three additional testing sessions, again at 1000, 700 and 400 msec. Only one subject was tested per day during the alcohol stage. Five weeks of data collection were required for the entire investigation. All data was collected using a PDP 11/34 computer system and was subsequently transferred to tape for further analysis.

4.0 DESCRIPTION OF THE DATA

For each manikin presentation, the data recorded by the computer system consisted of (1) a number between 1 and 16 identifying the particular view shown to the subject, (2) a code identifying whether the subject's response was correct, incorrect or missing, and (3) the amount of time in milliseconds between the onset of the stimulus and the response.

The first code represents the specific combination of orientation category (back-erect [BE], back-inverted [BI], front-erect [FE], front-inverted [FI]), target shape (circle [C] vs. square [S]) and side of correct response (left [L] vs. right [R]). This allowed measurement of any response differences associated with the different manikin figures.

Data was collected in individual 25-minute trials. A trial consisted of four periods of presentations with a series of 96 presentations per period. Within each series, the 16 possible manikin views were each shown six times, with the particular views ordered randomly within each 16-view subset. Thus, each trial consisted of 384 presentations.

4.1 Initial Training

In the initial stage of the study, each of the five subjects participated in a minimum of seven training trials, resulting in 2688 presentations per subject and a total of 13,440 presentations across all subjects. A partitioning of this total number shows that there were 3360 data points for each orientation category and 6720 data points for each level of the target shape and side of correct response factors.

4.2 Deadline Training

Following initial training, each subject participated in an additional 10 to 20 trials under various deadline conditions to gain practice in producing the data for the speed-accuracy functions. The number of trials for each subject was based on the amount of practice required for that subject to develop his ability to meet each particular deadline condition. Thus, an additional 3840 to 7680 data points per subject were collected in this stage of the study.

Minimal analysis of this data was performed due to the lack of uniformity in subject learning ability resulting in individualized training schedules for each subject.

4.3 Baseline and Alcohol

Three trials of baseline and three trials under the alcohol treatment were completed by each subject. These trials yielded the 11,520 data points representing the primary objective of the research effort.

4.4 Data Reduction

In total, data for over 44,000 manikin presentations were obtained during the five-week data collection period. All data, along with identification of subject, time and date of session and test condition, were transferred to magnetic tape. A data management scheme was devised to convert and store the data on the University of Oklahoma IBM 3081 for analysis using the Statistical Analysis System (SAS, 1982).

5.0 RESULTS

The results of the investigation will be presented in four sections: (1) manikin figures, (2) training patterns, (3) speed-accuracy tradeoff functions and (4) alcohol evaluation.

5.1 Manikin Figures

Several factors have been previously identified as having possible effects on response time and accuracy for the Manikin Task. From a training standpoint, trial number (1,2,...,7) is of primary importance. These performance changes over time will be discussed in section 5.2 on Training Patterns. Within each trial, individual periods (1,2,3,4) may also show response differences. With respect to individual manikin figures, the major factors are orientation category (BE, BI, FE, FI), target shape (C, S) and side of correct response (L, R). Finally, individual subject differences must also be examined.

5.1.1 Analysis of Variance Model

Based on the above factors, a repeated measures analysis of variance model including interaction effects was developed. The factors included in the model are summarized in Table 1 and a layout of the data for a single subject is given in Table 2.

Table 1. Summary of Factors for the Analysis of Variance Model.

FACTOR	LEVELS
Orientation Category	BE, BI, FE, FI
Target Shape	Circle, Square
Side of Correct Response	Left, Right
Trial Number	1,2,3,4,5,6,7
Period Number	1,2,3,4
Subject	A,B,C,D,E
Replication	1,2,3,4,5,6

Table 3 provides the results of the analysis of variance with respect to the main factors, all two-way interactions, and three-way interactions involving the subject variable. All higher-order interactions were nonsignificant at an alpha level of 0.01 except for the TARGET*SIDE*TRIAL*SUBJECT and SIDE*TRIAL*PERIOD*SUBJECT interactions. Throughout the analysis, there appeared to be strong individual subject interactions involving side of correct response and trial number. However, interpretation of these interactions is questionable at best.

Table 2. Data Layout for a Single Subject.

Orientation		BE				BI				FE				FI			
Target		C		S		C		S		C		S		C		S	
Side		L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
Trial	Period																
		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
1	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	2	(as above, six replications per cell)															
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6	1																
	2																
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7	1																
	2																
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	4																

Table 3. Analysis of Variance - Training Response Times.

SOURCE	DF	SS	MS	F
Orient	3	44160998	14720333	12.58*
Target	1	202547	202547	1.37
Side	1	5327351	5327351	2.29
Trial	6	210927099	35154516	22.19*
Period	3	8754586	2918195	13.91*
Subject	4	292523751	73130938	2526.81*
Orient*Subject	12	14045946	1170496	40.44*
Target*Subject	4	589633	147408	5.09*
Side*Subject	4	9323445	2330861	80.54*
Trial*Subject	24	38017491	1584062	54.73*
Period*Subject	12	2517862	209822	7.25*
Orient*Target	3	884750	294917	6.63*
Orient*Side	3	2238821	746274	1.03
Orient*Trial	18	2725135	151396	2.26*
Orient*Period	9	119579	13287	<1.00
Target*Side	1	128310	128310	9.88
Target*Trial	6	170929	28488	<1.00
Target*Period	3	120107	40036	1.35
Side*Trial	6	143701	23950	<1.00
Side*Period	3	5955	1985	<1.00
Trial*Period	18	6313230	350735	3.00*
Orient*Target*Subject	12	533687	44474	1.54
Orient*Side*Subject	12	8688266	724022	25.02*
Orient*Trial*Subject	72	4829497	67076	2.32*
Orient*Period*Subject	36	1438180	39949	1.38
Target*Side*Subject	4	51970	12993	<1.00
Target*Trial*Subject	24	819227	34134	1.18
Target*Period*Subject	12	355776	29648	1.02
Side*Trial*Subject	24	2993375	124723	4.31*
Side*Period*Subject	12	354645	29554	1.02
Trial*Period*Subject	72	8408857	116790	4.04*
ERROR	11200	324147860	28942	
TOTAL	13439	1046252859		

* - significant at alpha = 0.01

The mean response time for all training trials was 855 msec with 96.60% correct responses, 2.75% incorrect responses and 0.65% missed responses. The mean response time for the correct responses (876 msec) was noticeably faster than the mean response time for the incorrect responses (910 msec). Discussion of the analysis of variance results for each of the main factors is included within the following sections.

5.1.2 Orientation Category

Response time and accuracy data for the four orientations are presented in Table 4. The data represent summary statistics collapsed across all training trials (1 through 7) and all subjects. Mean response times for correct and incorrect responses are presented separately.

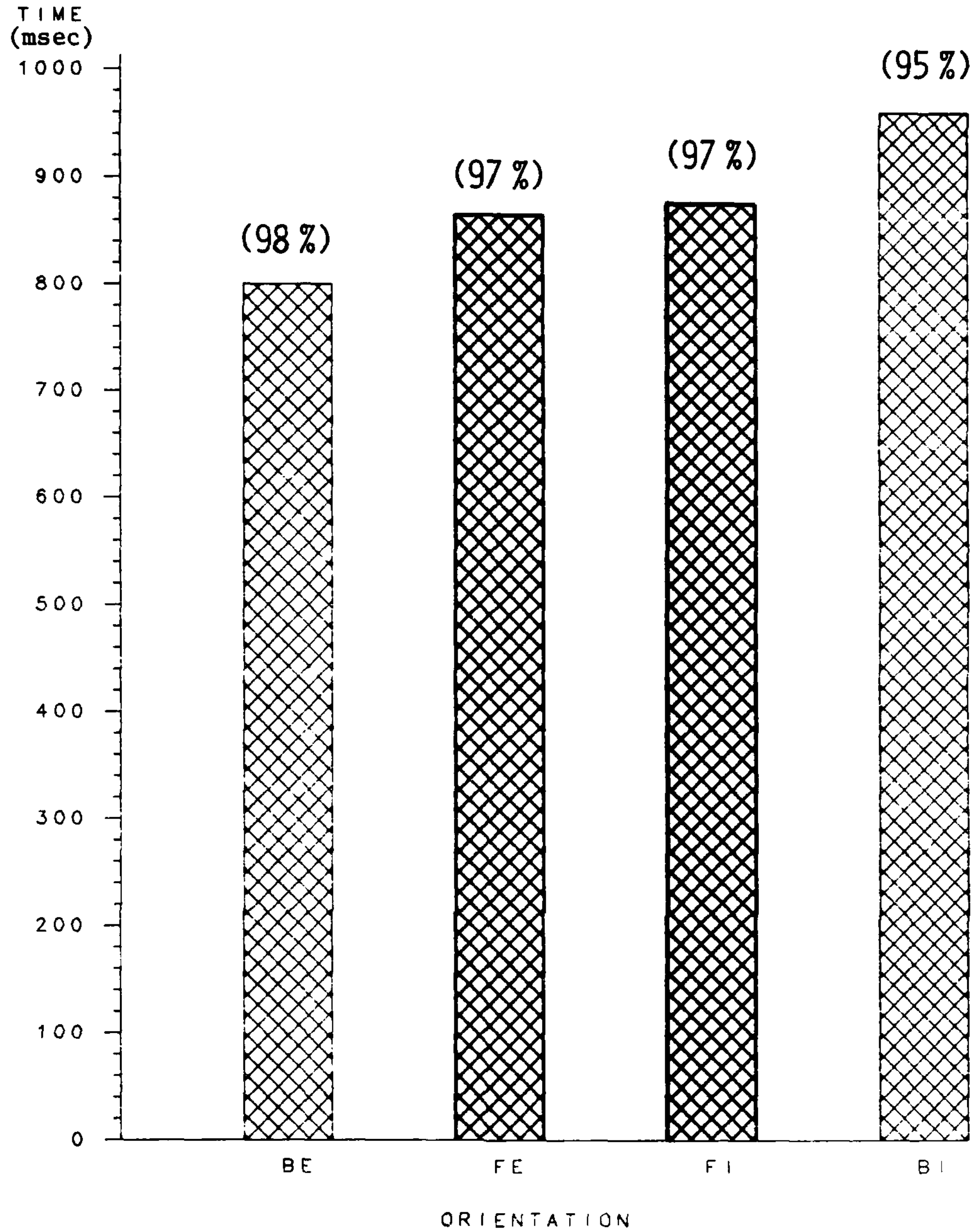
Table 4. Training Data by Orientation Category.

		BE	BI	FE	FI
Response Time (msec)					
	Overall Mean	808	969	873	888
	Standard Dev.	(258)	(303)	(257)	(271)
	Mean Correct	802	956	871	877
	Mean Incorrect	862	963	810	971
Accuracy					
	% Correct	98.16	94.71	96.77	96.74
	% Incorrect	1.44	4.11	2.88	2.56
	% Missed	0.40	1.18	0.35	0.70

BE=Back-Erect BI=Back-Inverted
FE=Front-Erect FI=Front-Inverted

There were highly significant differences in the response times and accompanying differences in the accuracy levels for the orientations. The order of difficulty was identical to that reported by Reader et al. (1981). The easiest orientation was the back-erect figure (808 msec, 98%) which provided a direct spatial association to the subject viewing the CRT. Next, the front-erect and front-inverted figures had almost identical response times (880 msec) and accuracies (97%). The back-inverted figure was most difficult (969 msec, 95%) requiring an average 160 msec of additional response time above that of the back-erect figure. These results are illustrated in Figure 2. The differences in accuracy were examined using a Chi-square contingency analysis and found to be significant with $p < 0.0001$.

A comparison of response times for correct vs. incorrect responses failed to reveal a consistent pattern. Independent of orientation, some subjects responded more quickly on correct responses while others responded more quickly on incorrect responses.



BE - Back/Erect FE - Front/Erect

BI - Back/Inverted FI - Front/Inverted

(xx) represent percentage correct

Figure 2. Training Data - Response Time vs. Orientation.

5.1.3 Target Shape

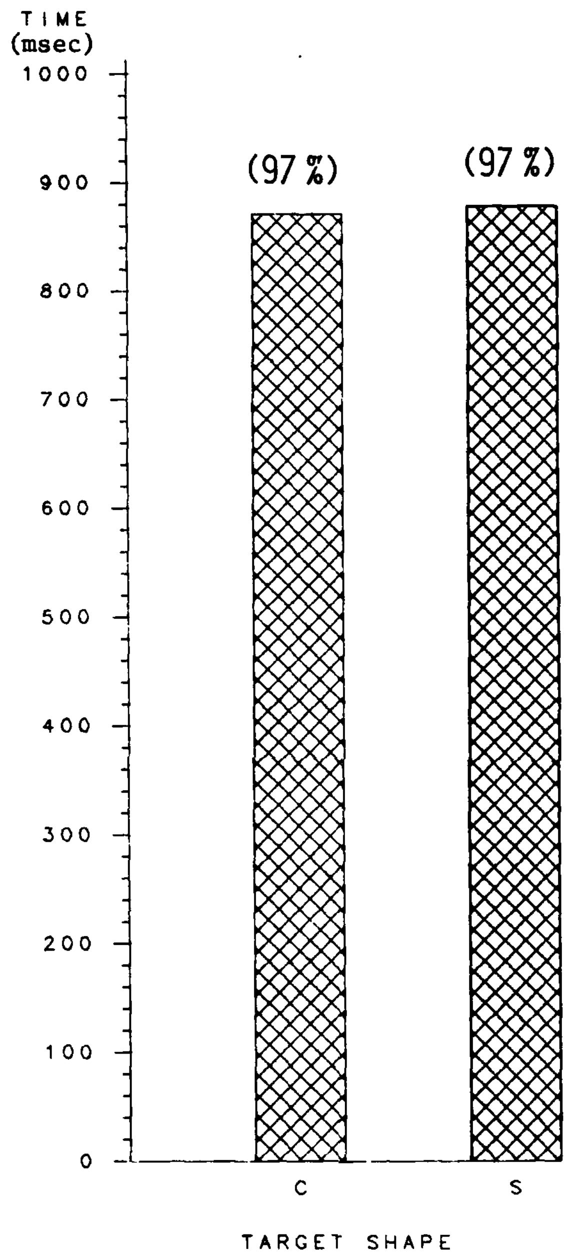
As observed from Table 5 and Figure 3 and verified by analysis of variance and Chi-square tests, there were absolutely no differences in response time or accuracy between the circle and square targets. This confirms the results obtained by Reader et al. (1981). However, the mean correct response time was lower than the mean incorrect response time for circle targets. The times were approximately equal for the square targets. The reason for this difference was not evident.

Table 5. Training Data by Target Shape.

		Circle	Square
Response Time (msec)			
	Overall Mean	881	889
	Standard Dev.	(278)	(280)
	Mean Correct	871	896
	Mean Incorrect	923	880
Accuracy			
	% Correct	96.57	96.62
	% Incorrect	2.74	2.76
	% Missed	0.69	0.62

5.1.4 Side of Correct Response

Of particular interest was the effect of side of correct response (L vs. R). In previous versions of the task, the subject made a "left" response by pressing a button in his left hand and a "right" response by pressing a button in his



C - Circle S - Square

(xx) represent percentage correct

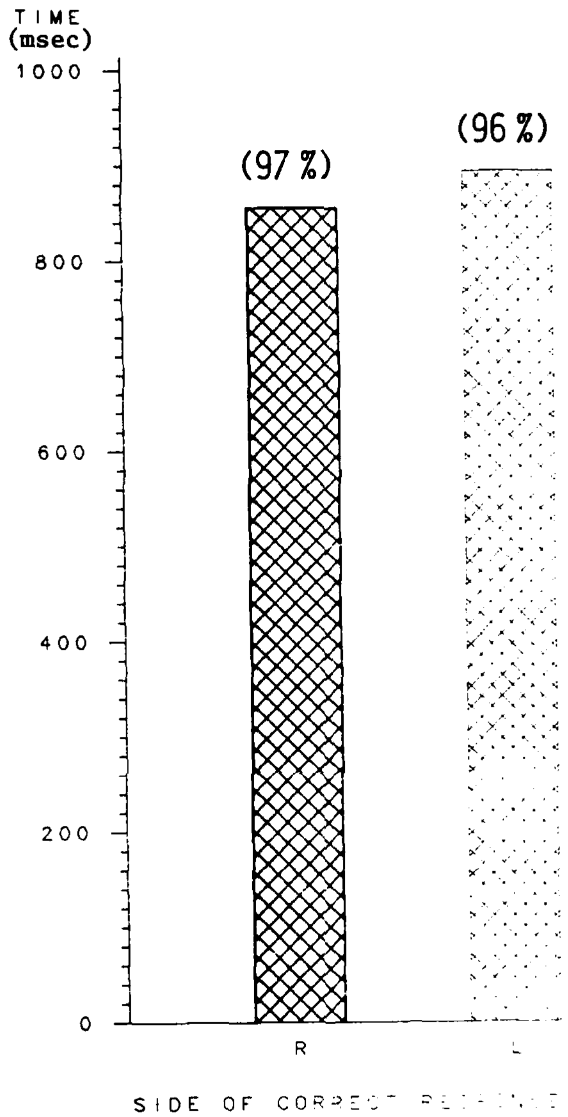
Figure 3. Training Data - Response Time vs. Target Shape.

right hand. It was hypothesized that this might explain the difference in left vs. right response times. A different method of obtaining subject responses was used in this investigation. Two buttons, 6.4 cm apart, were mounted on a response panel. The subject registered a response by pressing either the left or right button, always using the same finger of the right hand. Thus, the data would indicate if the difference between left-side and right-side responses was related to central processing vs. motor differences.

As seen from Table 6 and Figure 4, there was a tendency for faster right-side responses. Although the magnitude of the difference (40 msec) was larger than that reported by Reader, it was not even marginally significant as determined by the analysis of variance. Furthermore, the accuracy levels were almost identical. Thus, the data does not confirm any statistically significant difference in spatial processing performance related to left vs. right side of response. The differences reported by Reader, if

Table 6. Training Data by Side of Correct Response.

	Left	Right
Response Time (msec)		
Overall Mean	905	865
Standard Dev.	(291)	(265)
Mean Correct	894	858
Mean Incorrect	905	914
Accuracy		
% Correct	96.35	96.83
% Incorrect	2.80	2.70
% Missed	0.85	0.47



L - Left   R - Right

(xx) represent percentage correct

Figure 4. Training Data - Response Time vs. Side of Correct Response.

statistically significant, were possibly caused by the additional time required by right-handed subjects to execute responses with their left hands. In both studies, all subjects were right-handed.

5.1.5 Period

Response time and accuracy data as a function of period number are presented in Table 7. There was a progressive decrease in response time and a corresponding increase in accuracy from period 1 (923 msec, 96%) through period 4 (853 msec, 97%). Analysis of variance and subsequent pairwise comparisons verified a highly significant difference between the first and fourth periods. This difference was evident across all subjects and was most pronounced in the early trials (1 through 4). As seen from Table 8, the difference was less evident in the late trials (5 through 7). This explains the significant trial by period interaction.

Table 7. Training Data by Period.

	PERIOD			
	1	2	3	4
Response Time (msec)				
Overall Mean	923	889	873	853
Standard Dev.	(309)	(285)	(267)	(264)
Mean Correct	906	882	900	848
Mean Incorrect	979	899	867	844
Accuracy				
% Correct	95.70	96.88	96.77	97.04
% Incorrect	3.13	2.56	2.75	2.56
% Missed	1.17	0.56	0.48	0.40

Table 8. Training Response Times by Period - Early vs. Late Trials.

	PERIOD			
	1	2	3	4
Early	1016	970	938	917
Late	795	784	792	766

Again, no consistent pattern existed with respect to the mean response times for correct vs. incorrect responses. However, separating early vs. late trials did reveal a decrease in mean correct response time with increasing period number for the early trials.

5.1.6 Subject Differences

There were large individual differences in spatial processing ability between the five subjects with respect to response time (710 msec to 1130 msec) and accuracy (99.6% to 92.8%). These differences are summarized in Table 9. There was little correlation between response time and accuracy except that the subject with the slowest time also had the lowest accuracy.

For response time, all two-way interactions involving subjects were highly significant. With respect to orientation category, Figure 5 shows that back-inverted was most difficult for all subjects and back-erect was easiest for most subjects. Difficulty level for the other orientations differed with subject. The pattern for accuracy was even less orderly.

Table 9. Training Data by Subject.

		SUBJECT				
		A	B	C	D	E
Response Time (msec)						
	Overall Mean	796	1130	710	964	823
	Standard Dev.	(229)	(335)	(158)	(249)	(168)
	Mean Correct	796	1104	711	958	822
	Mean Incorrect	759	1143	671	928	1160
Accuracy						
	% Correct	95.77	92.84	97.73	97.20	99.58
	% Incorrect	4.13	4.72	2.27	2.18	0.39
	% Missed	0.10	2.44	0.00	0.62	0.03

The TARGET*SUBJECT interaction, although statistically significant, was minimal from a practical standpoint. Three subjects performed slightly better with circle targets and one subject slightly better with square targets. Accuracies for all subjects were consistently equal for circle and square targets.

The SIDE*SUBJECT interaction was highly significant, with two subjects showing a slight and one subject a major response time advantage with right-side responses. Accuracies for left vs. right were nearly identical for each subject.

With respect to the PERIOD*SUBJECT interaction, some subjects did not show as strong an improvement from period 1 to period 4 as did others. The TRIAL*SUBJECT interaction will be discussed in the following section.

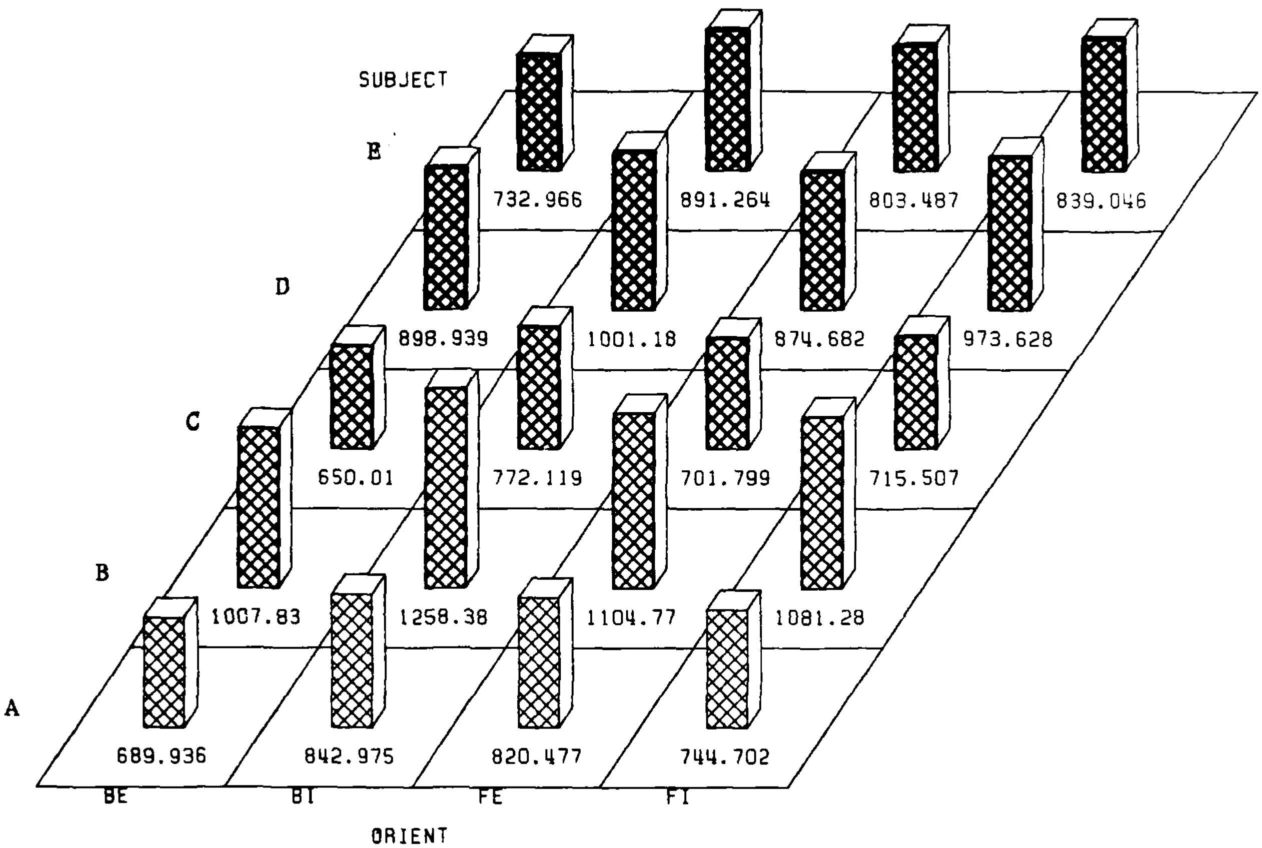


Figure 5. Response Time vs. Orientation by Subject

The significant higher-order interactions involving subjects serve to reinforce the fact that strong individual differences existed. Further explanation of these interactions will not be attempted.

5.2 Training Patterns

Learning curves were derived to fit the data for the first seven sessions, both on an individual subject and combined basis. Least-squares regression techniques using a power function and a negative exponential function were performed. Separate plots were also generated for the various levels of orientation category, target shape and side of correct response to isolate those levels which have an inherently slower learning rate than the others.

5.2.1 Overall

Table 10 presents the response data as a function of trial number to illustrate the learning characteristics of the task. With the exception of trial 1, there was little change in the percent correct throughout the training stage of the investigation. However, there was a consistent

Table 10. Training Data by Trial Number.

	TRIAL						
	1	2	3	4	5	6	7
Response Time (msec)							
Overall Mean	1149	958	883	851	819	788	744
Standard Dev.	(342)	(290)	(244)	(240)	(213)	(200)	(178)
Mean Correct	1117	945	879	850	817	786	742
Mean Incorrect	1307	1044	825	823	794	774	793
Accuracy							
% Correct	94.06	96.98	96.72	96.09	97.86	97.71	96.72
% Incorrect	2.97	2.03	2.76	3.70	2.04	2.19	3.23
% Missed	2.97	0.99	0.52	0.21	0.10	0.10	0.05

decline in the number of missed responses from a total of 57 in the first trial to 1 out of 1920 in the seventh trial. This decline was confirmed by a Chi-square contingency table analysis which showed significant differences at $p < 0.0001$. Response time means and standard deviations decreased according to a standard learning curve as shown in Figure 6.

5.2.2 Individual Subject

Summaries of the response data as a function of trial number for each subject are provided in Appendix A. Figure 7 provides a comparison of the response times over the trials for the five subjects. For all but the best subject, the greatest improvements occurred in the first two trials. With the exception of one data point (subject A, trial 1), the performance rank order of the subjects was maintained throughout all seven trials. This reinforces the stability property of the Manikin Task. A plot of response time standard deviation (Figure 8) shows a similar but less stable pattern of improvement.

No clear pattern of response accuracy emerged for the different subjects with one exception. All subjects showed a constant decrease in the number of missed responses over time. Two subjects had missed responses only in the first trial and one subject had no missed responses out of 2688 stimuli.

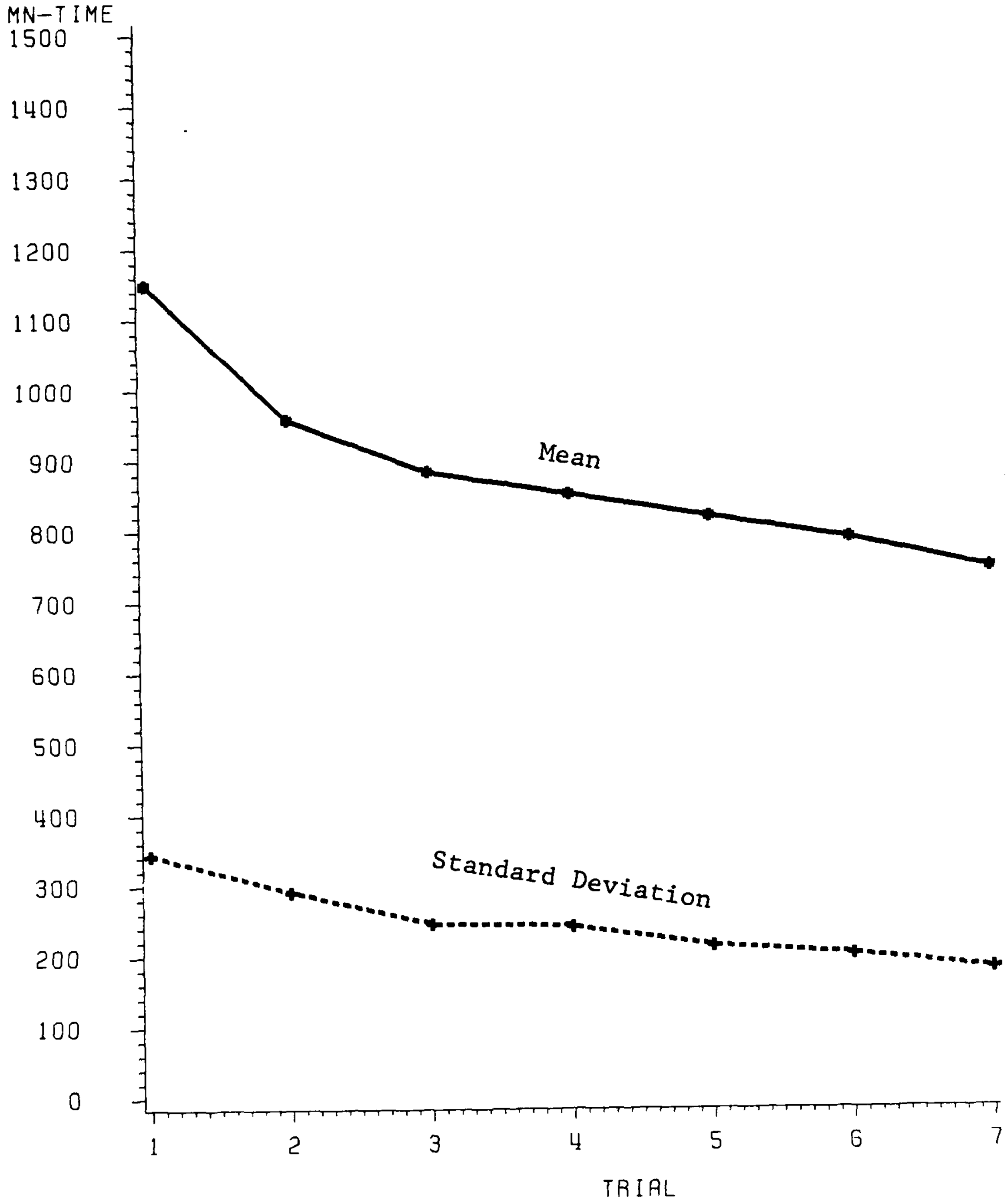


Figure 6. Response Time Mean and Standard Deviation vs. Trial Number.

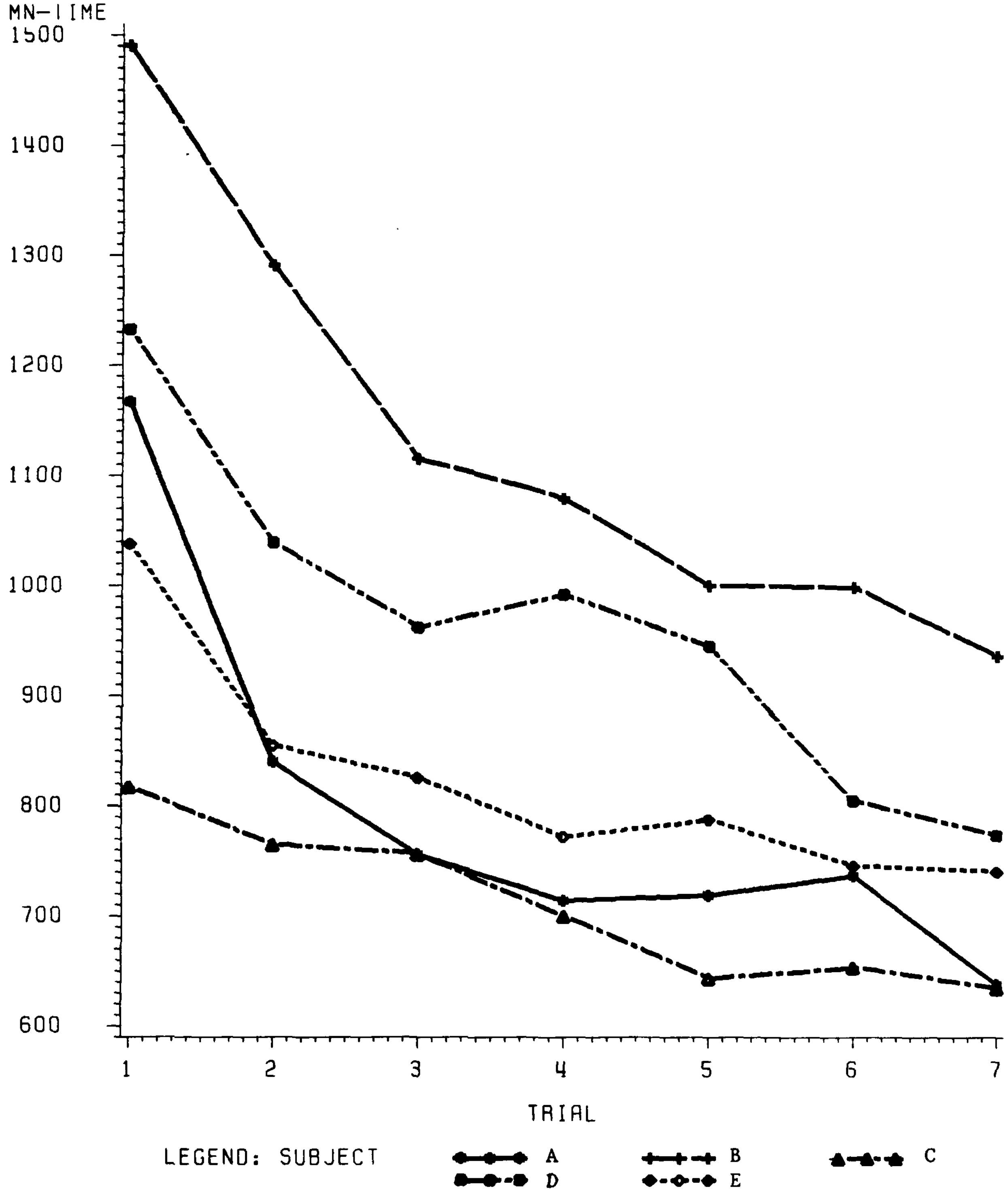


Figure 7. Response Time Mean vs. Trial Number by Subject.

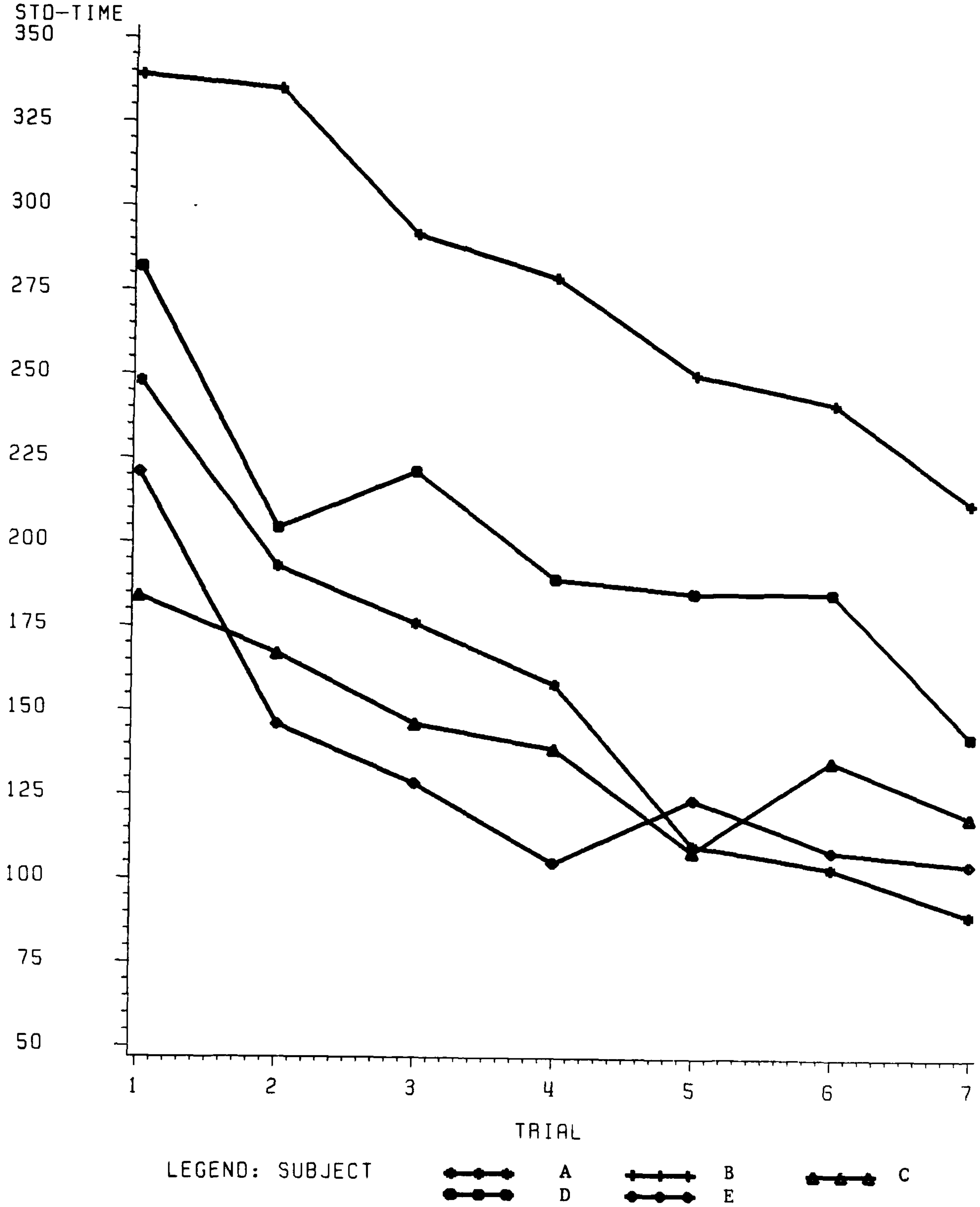


Figure 8. Response Time Standard Deviation vs. Trial Number by Subject.

5.2.3 Orientation, Target and Side

Plots of response time vs. trial for orientation category (Figure 9), target shape (Figure 10) and side of correct response (Figure 11) all indicate the remarkable stability of the task over time with respect to each of these factors. The slight ORIENTATION*TRIAL interaction indicated by the analysis of vaiance is barely observable in Figure 9, which does clearly show the relative difficulty of the different orientations. The independence of target shape is easily seen in Figure 10 as is the slight but constant left vs. right difference in Figure 11.

5.2.4 Learning Curves

Least-squares regression using the SAS NLIN procedure was performed to generate response time learning curves for the overall data and for each subject. Two potential functions were examined:

$$RT = A * (TRIAL**B) \quad \text{with } B < 0 \qquad (1)$$

$$RT = A + B * EXP(-C * TRIAL) \qquad (2)$$

In all cases, function (2) yielded the smallest residual sum of squares partially due to the increased number of parameters to be estimated. Figure 12 shows the negative exponential regression curve (and indicates the adequacy of fit) for the overall data.

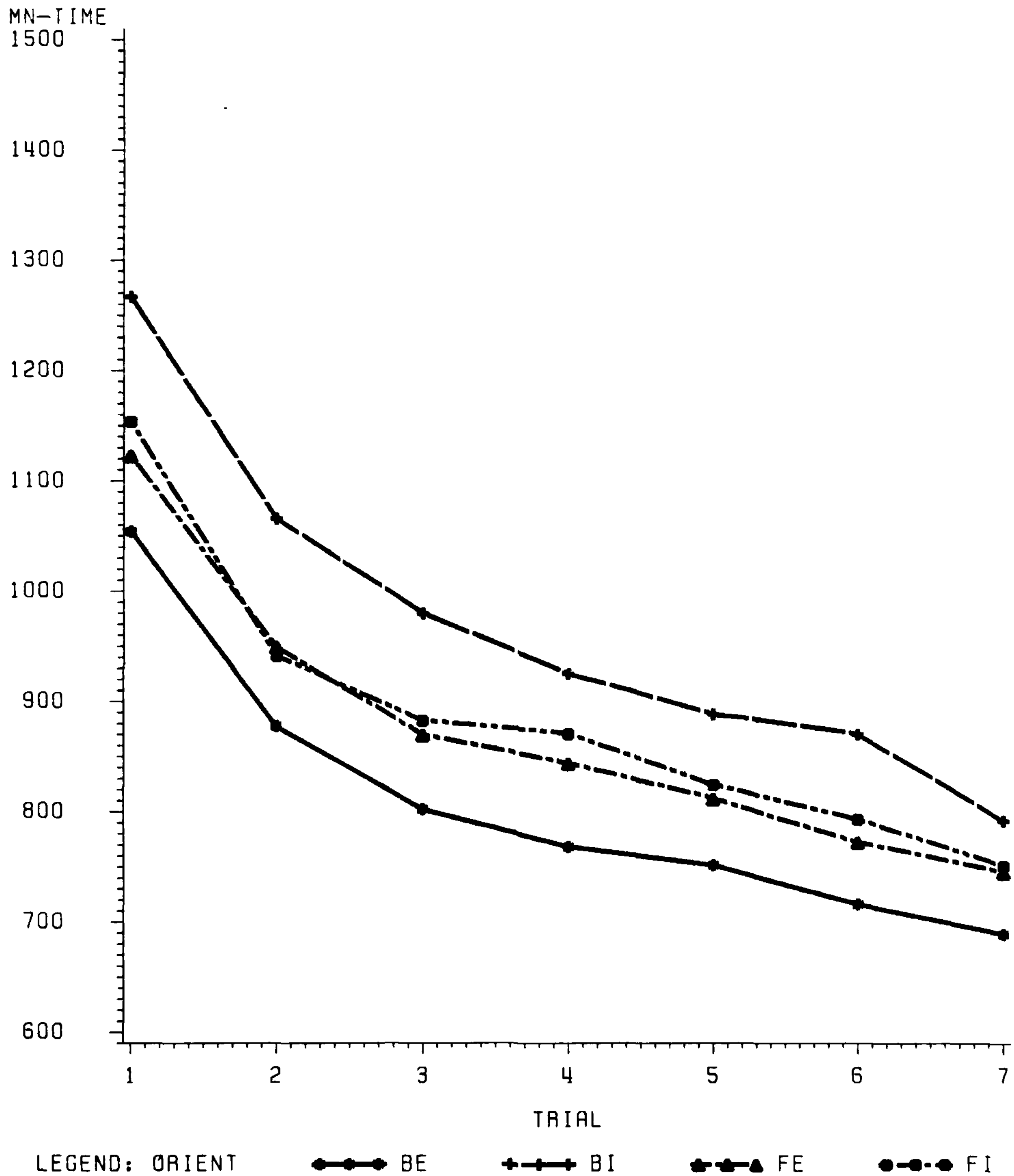


Figure 9. Response Time vs. Trial Number by Orientation.

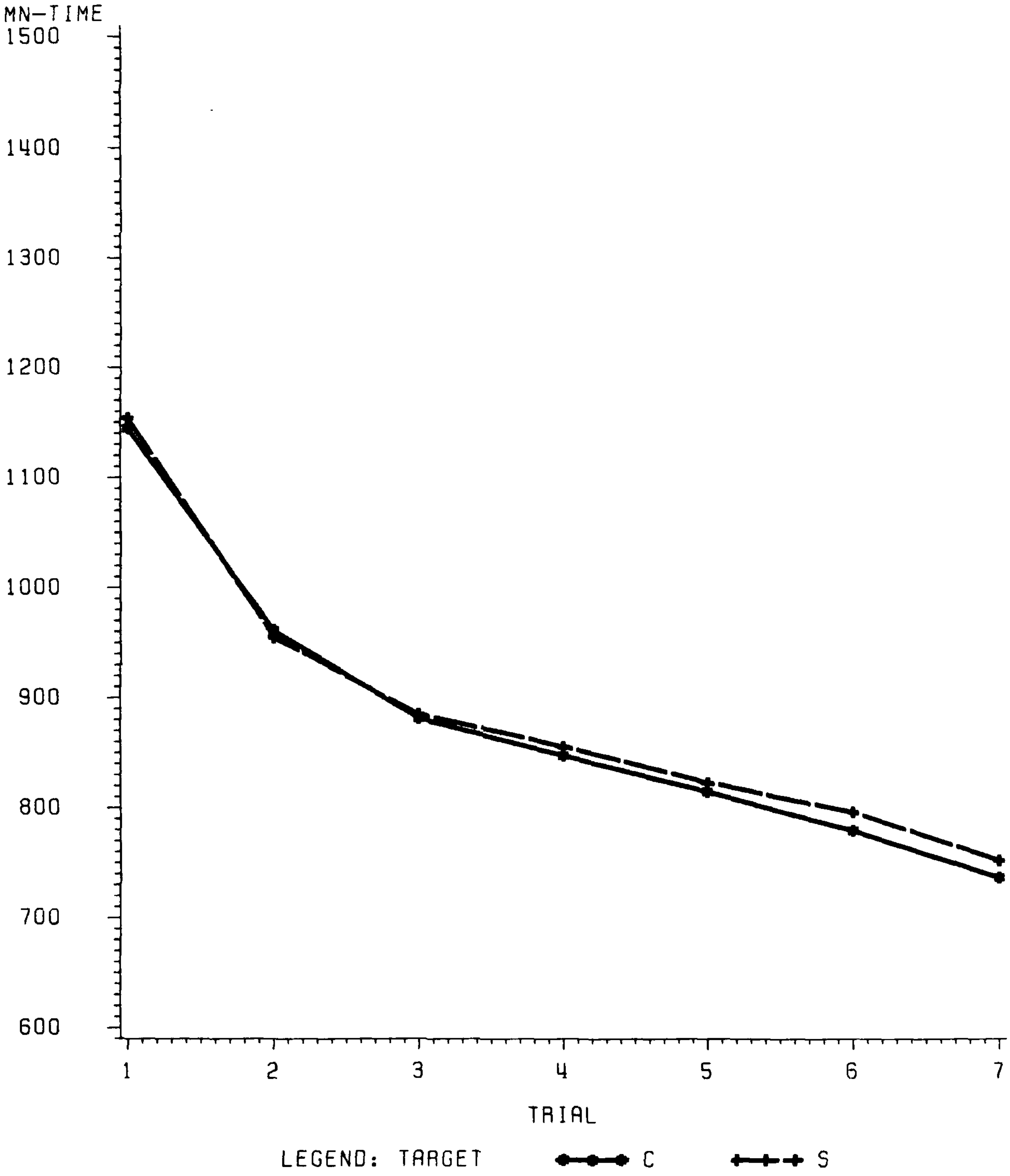


Figure 10. Response Time vs. Trial Number by Target Shape.

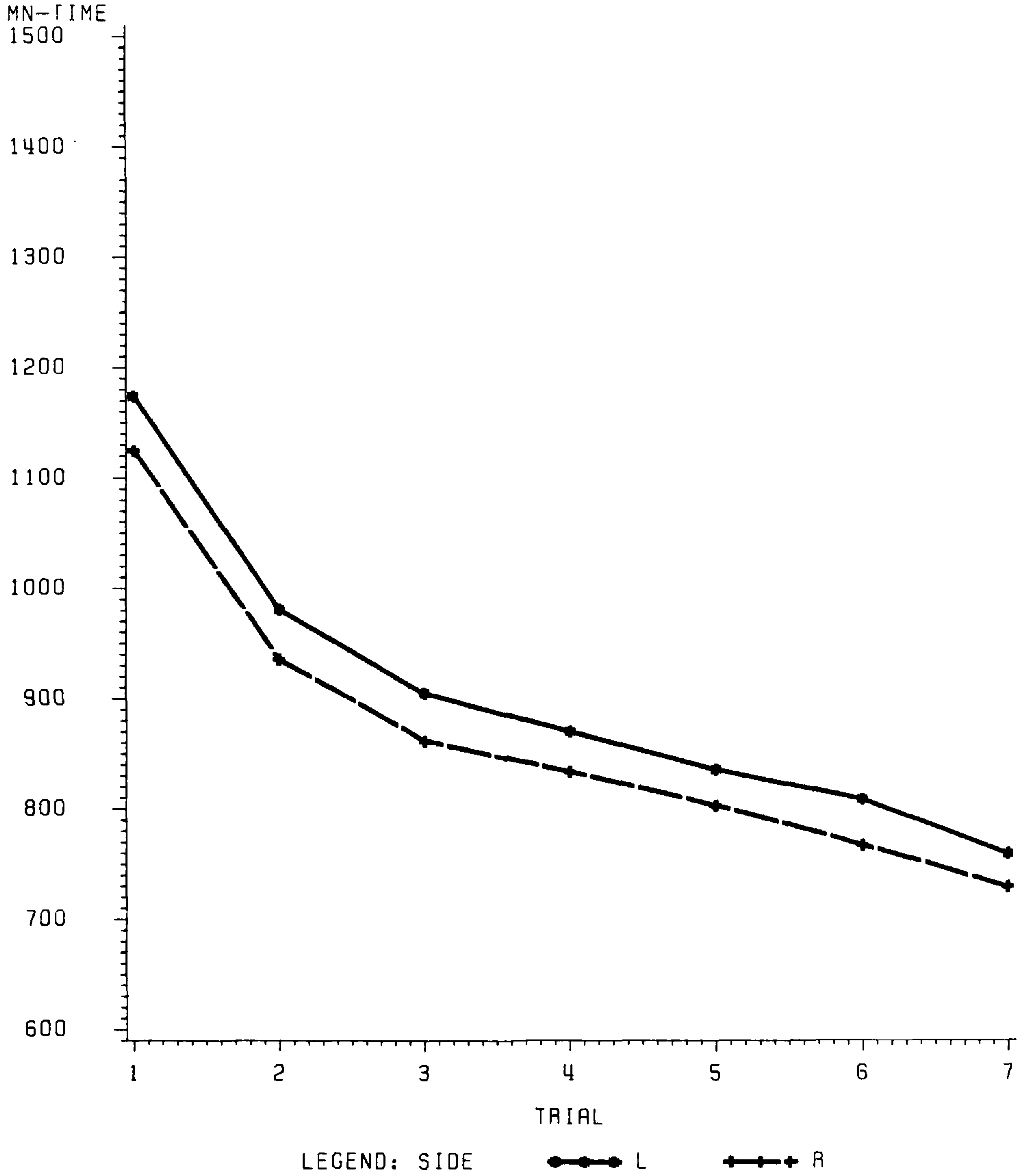


Figure 11. Response Time vs. Trial Number by Side of Correct Response.

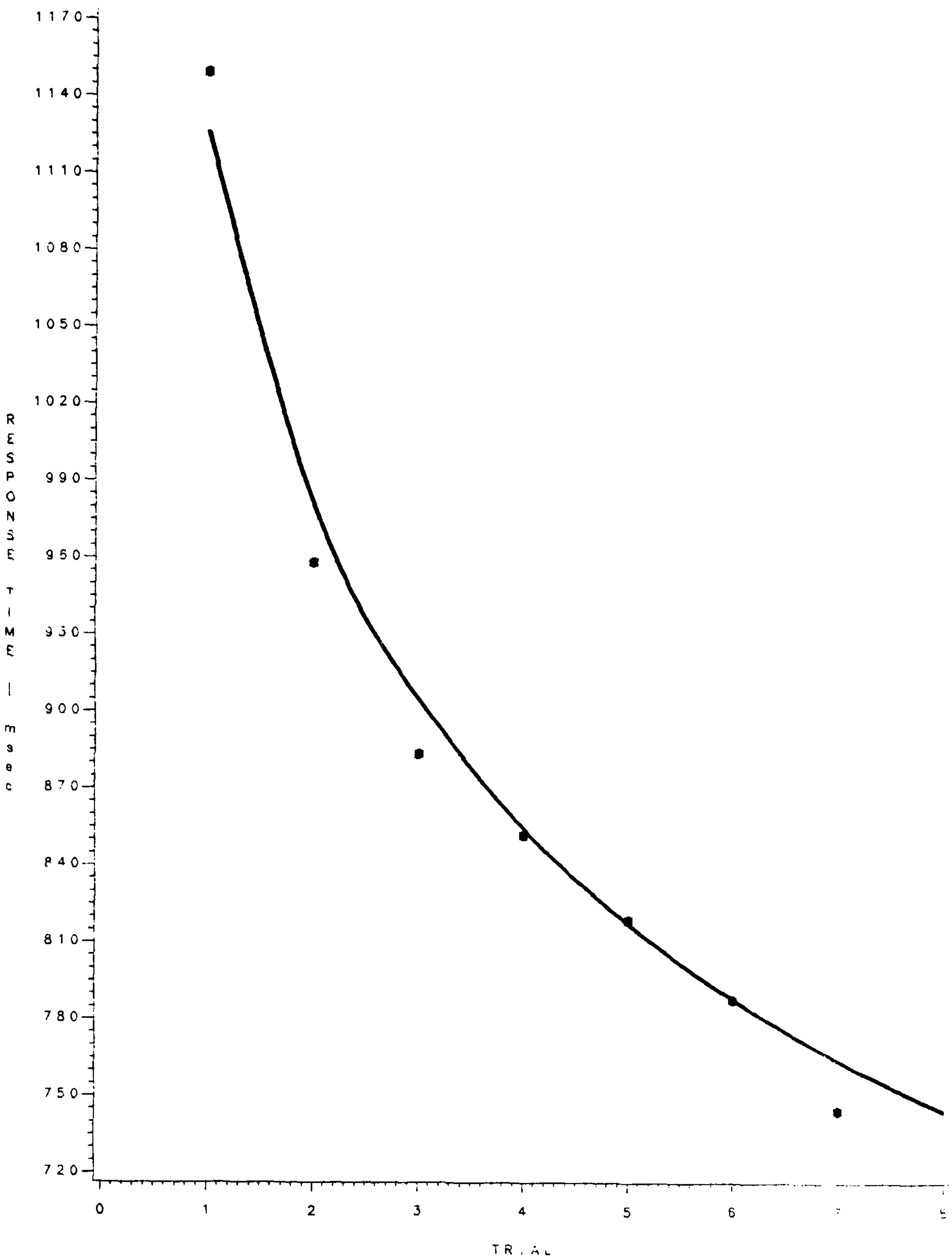


Figure 12. Learning Curve Least-Squares Regression of Response Time vs. Trial Number.

Table 11 provides a comparison of the regression parameters for both functions and all five subjects. In function (2), the parameters B and C together indicate the individual subject's rate of learning as can be verified by comparison with Figure 6. As the trial number increases, the exponential term approaches zero. Thus, the parameter A represents the asymptotic level of response time after the task is fully learned. For three of the subjects (A,B,E), the value of A was very close to the mean response time for the seventh trial. For the other two subjects (C,D), the value of A was much lower than the seventh trial mean indicating that performance improvements with additional training might have been expected.

Table 11. Learning Curve Regression Parameters by Subject.

	FUNCTION 1			FUNCTION 2			
	A	B	Resid. SS	A	B	C	Resid. SS
SUBJECT							
A	1111	-0.29	17932	676	1274	0.97	9085
B	1481	-0.22	8821	952	932	0.54	4240
C	832	-0.13	2563	525	350	0.18	1477
D	1238	-0.22	15306	584	730	0.18	14575
E	999	-0.16	7127	758	670	0.89	1971

5.2.5 Acquisition of Stabilized Performance

Although the previous analyses were based on the first seven trials, most subjects required eight trials to meet the stability criterion of less than ±5% deviation from the mean of the preceding two trials. A comparison of the actual deviation vs. the predicted deviation based on the negative exponential curve fit shows the extent to which the termination criterion was satisfied (Table 12). An insufficient number of trials at the stabilized (flat) portion of the learning curve prevented any further analysis of the differential stability of the task.

Table 12. Response Time Deviation at Training Termination.

		SUBJECT				
		A	B	C	D	E
Trial 7						
	Actual %	-12.4	-6.3	-2.2	-11.6	-3.4
	Predicted %	-0.8	-2.8	-4.8	-7.6	-0.6
Trial 8						
	Actual %	-8.9	+3.2	---	-3.9	+3.8
	Predicted %	-0.3	-1.7	---	-6.7	-0.1

% Deviation of Trial N =

$$[RT_N-(RT_{N-1}+RT_{N-2})/2]/[(RT_{N-1}+RT_{N-2})/2] * 100$$

Based on the <u>predicted</u> values, all subjects except subject D satisfied the stopping criterion. This reinforces the previous statement concerning the discrepancy between the value of parameter A for subject D and the response time for trial 7. Subject C, who was also identified for further improvement based on the value of parameter A marginally met the stopping criterion based on the curve fit.

5.3 Speed-Accuracy Tradeoff

The deadline procedures used to force faster response times successfully produced a shift in both response time and accuracy. Mean values for these variables under baseline conditions are given in Table 13. A further breakdown by period is given in Appendix B.

Table 13. Baseline Data under Deadline Conditions.

Response Time (msec) / Accuracy (% correct)	DEADLINE (msec) 400	700	1000
SUBJECT			
A	519	601	655
	71	98	99
B	383	533	540
	56	96	98
C	654	688	743
	79	88	95
D	554	629	714
	72	89	98
E	431	576	608
	62	96	98
Mean	508	605	652
	68	93	98

All subjects produced significantly different reponse times and accuracies under all three deadlines. For the 1000 and 700 msec deadlines, subjects were able to consistently beat the deadline for all stimuli. Only one subject consistently met the 400 msec deadline and this was with a considerable sacrifice in accuracy (56%). Other subjects responded up to 250 msec late on the average.

Significant declines in accuracy accompanied the reduced reponse times. Statistical analysis indicated that all three deadlines produced significantly different ($p < 0.01$) levels of accuracy as measured by the percentage of correct responses. To summarize, the percentage of correct responses dropped from 98% at 1000 msec to 93% at 700 msec followed by a sharp decline to 68% at 400 msec. A combined analysis of variance for the baseline and alcohol conditions was performed for both response time and percentage correct. These results are presented in the following section.

Although the changes in response time and accuracy were quite pronounced, attempts at constructing realistic speed-accuracy tradeoff functions met with limited success. Primarily due to the large subject variability, an adequate overall speed-accuracy relationship could not be obtained. This difficulty is easily seen in the "scatter plot" in Figure 13 which shows a least-squares linear regression fit of percent correct vs. reaction time for the baseline and alcohol conditions. Various transformations of the accuracy data did not improve the ability to generate meaningful tradeoff functions. In lieu of this approach, individual speed-accuracy plots were generated for each subject under baseline and alcohol. Further discussion of these speed-accuracy plots is included in the following section on Alcohol Evaluation.

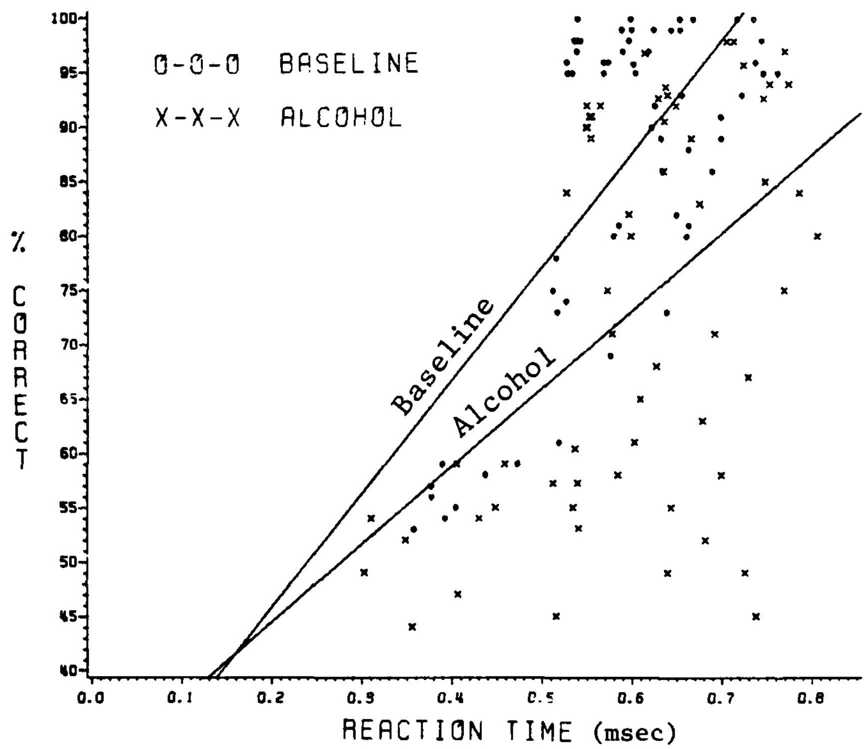


Figure 13. Accuracy vs. Reaction Time - Least-Squares Linear Regression for Baseline vs. Alcohol.

5.4 Alcohol Evaluation

Mean values of response time and accuracy for each subject under the alcohol condition are given in Table 14. A further breakdown by period may be found in Appendix B.

Table 14. Alcohol Data by Subject.

Response Time (msec) / Accuracy (% correct)	DEADLINE (msec) 400	700	1000
SUBJECT			
A	533	630	723
	59	94	96
B	423	546	556
	54	89	91
C	696	660	774
	49	61	76
D	602	561	762
	58	68	92
E	330	596	648
	50	74	90
Mean	517	599	693
	54	77	89

On the average, response times under alcohol were slightly higher than under baseline conditions. In every instance (15 comparisons), accuracy under alcohol was lower than under baseline. This relationship held for all subjects and all deadlines. The following parts of this section provide separate discussions of (1) BAC levels, (2) response time, (3) accuracy and (4) speed-accuracy tradeoff.

5.4.1 BAC Levels

The alcohol administration procedure successfully produced the desired BAC level of 0.08% within ± 0.01% for all subjects. Examination of the breath-analysis readings taken prior to the start of the session and between periods within each session revealed that the BAC levels remained relatively constant throughout the testing. Thus, the administration of a maintenance dose proved extremely beneficial. In all cases, BAC levels did not begin to fall until a substantial time following completion of the testing.

5.4.2 Response Time

A combined analysis of variance was performed on the response time data for the baseline and alcohol conditions (Table 15). Although there were significant differences between the three deadline conditions, there was no significant difference between baseline and alcohol. This indicated the ability of the subjects to respond quickly even in the intoxicated state.

However, as with the baseline data, subjects were able to meet the deadline only under the 700 msec and 1000 msec conditions. The significant DEADLINE*SUBJECT interaction emphasizes that the subjects differed in their ability to

Table 15. Analysis of Variance for Response Time.

SOURCE	DF	SS	MS	F
Alcohol	1	6049	6049	2.91
Deadline	2	512846	256423	14.56*
Period	3	2820	940	<1.00
Subject	4	653683	163421	204.53*
Alcohol*Subject	4	8316	2079	2.60
Deadline*Subject	8	140900	17612	22.04*
Period*Subject	12	12224	1019	1.28
Alcohol*Deadline	2	11766	5883	1.18
Alcohol*Period	3	2187	729	<1.00
Deadline*Period	6	3753	626	<1.00
Alcohol*Deadline*Subject	8	39874	4984	6.24*
Deadline*Period*Subject	24	32632	1360	1.70
Alcohol*Deadline*Period	6	9291	1548	1.94
ERROR	36	28755	799	
TOTAL	119	1465097		

* - significant at alpha = 0.01

meet the deadlines. The fact that the differential ability to meet deadlines with and without alcohol was not the same for all subjects is verified by the significant ALCOHOL*DEADLINE*SUBJECT interaction. The nonsignificant ALCOHOL*SUBJECT interaction provides additional evidence that on the average each subject had an equal ability to meet deadlines regardless of alcohol level.

A comparison of the response times under the 1000 msec baseline condition with the trial 7 response times reveals that only one subject showed a drastic improvement following the additional deadline training trials. Two subjects showed a slight improvement and the other two a performance decrement. Thus, it is safe to assume that all but one of the subjects had reached stable performance on the task by the end of the training trials. This subject showed marked improvement but was at a stable level prior to the baseline/alcohol trials.

5.4.3 Accuracy

The analysis of variance results for percentage correct are presented in Table 16. As mentioned previously, significant declines in accuracy accompanied the shorter deadline conditions. More importantly, there was a significant reduction

Table 16. Analysis of Variance for Accuracy.

SOURCE	DF	SS	MS	F
Alcohol	1	5088	5088	14.04*
Deadline	2	23248	11624	38.34*
Period	3	21	7	<1.00
Subject	4	1511	378	17.43*
Alcohol*Subject	4	1450	362	16.71*
Deadline*Subject	8	2424	303	13.97*
Period*Subject	12	510	42	1.94
Alcohol*Deadline	2	320	160	2.86
Alcohol*Period	3	138	46	2.09
Deadline*Period	6	71	12	<1.00
Alcohol*Deadline*Subject	8	449	56	2.58
Deadline*Period*Subject	24	1064	44	2.03
Alcohol*Deadline*Period	6	88	15	<1.00
ERROR	36	781	22	
TOTAL	119	37161		

* - significant at alpha = 0.01

in accuracy with the administration of alcohol. At 1000 msec, the mean percentage correct dropped from 98% to 89%. The reduction at 700 msec was from 93% to 77% and at 400 msec, from 68% to 54%. This final level approaches the results that would be obtained by merely guessing at the correct response.

There were significant accuracy differences between subjects but the variability was not as large as with response time. The significant ALCOHOL*SUBJECT and DEADLINE*SUBJECT interactions again illustrate the differing effects of alcohol and deadline conditions on individual subjects.

As with response time, there was no significant difference in accuracy level between periods. In addition, no other interactions were significant. This demonstrates the appropriateness of an additive model with respect to the two main factors of interest, alcohol and deadline.

5.4.4 Speed-Accuracy Tradeoff

Table 17 summarizes the speed-accuracy tradeoff for the baseline and alcohol conditions averaged across all subjects. The consistency of response times for baseline and alcohol is again evident in this comparison. The decline in accuracy under the influence of alcohol is also evident showing a relative change of 9% at 1000 msec, 17% at 700 msec and 21% at 400 msec.

A graph of percentage correct vs. deadline condition (Figure 14) clearly shows the speed-accuracy relationship under baseline and alcohol conditions. The administration of alcohol caused a downward shift of the entire speed-accuracy function rather than a criteria shift along the same

Table 17. Baseline vs. Alcohol Speed-Accuracy Tradeoffs.

Time(msec) / Accuracy	BASELINE	ALCOHOL	DIFFERENCE	% DIFFERENCE
DEADLINE				
400	508	517	9 msec	1.8
	68%	54%	-14%	-20.6
700	605	598	-7 msec	-1.2
	93%	77%	-16%	-17.2
1000	652	693	41 msec	5.9
	98%	89%	-9%	-9.2

function. This may also be interpreted as a shift in the RT intercept rather than a change in slope although a slight change in slope was observed for some subjects.

Speed-accuracy plots for individual subjects are given in Figures 15 throught 19. As observed from the figures, there were minor variations in the form of the function but all subjects showed the same downward shift under the alcohol condition.

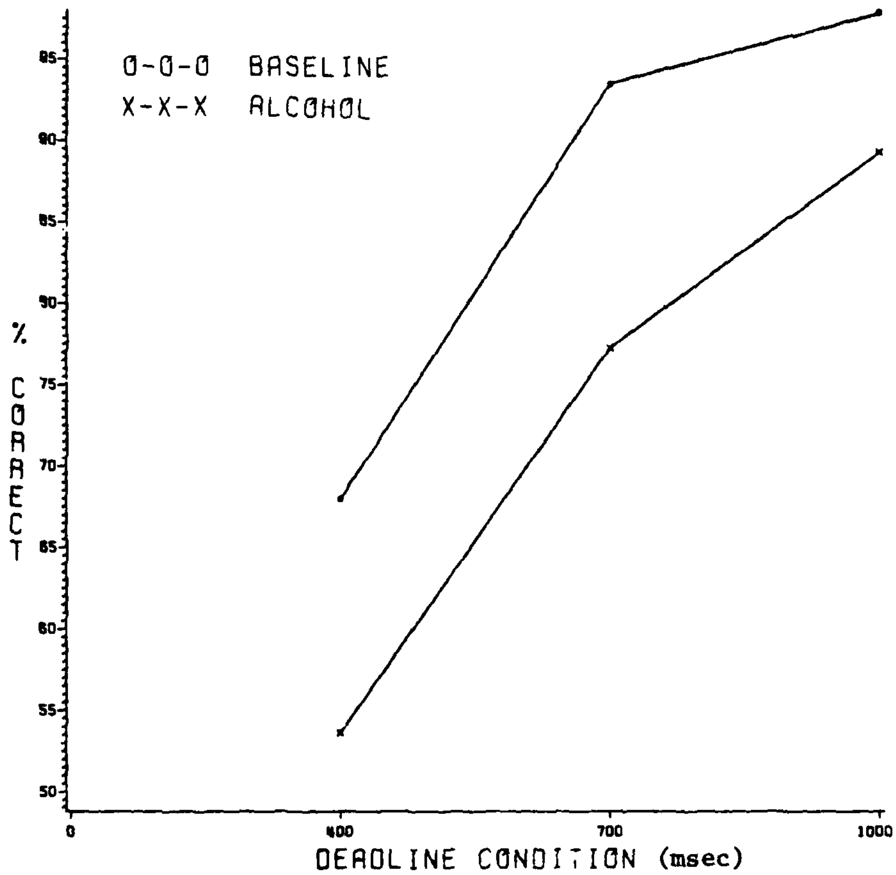


Figure 14. Accuracy vs. Deadline Condition by Alcohol Level.

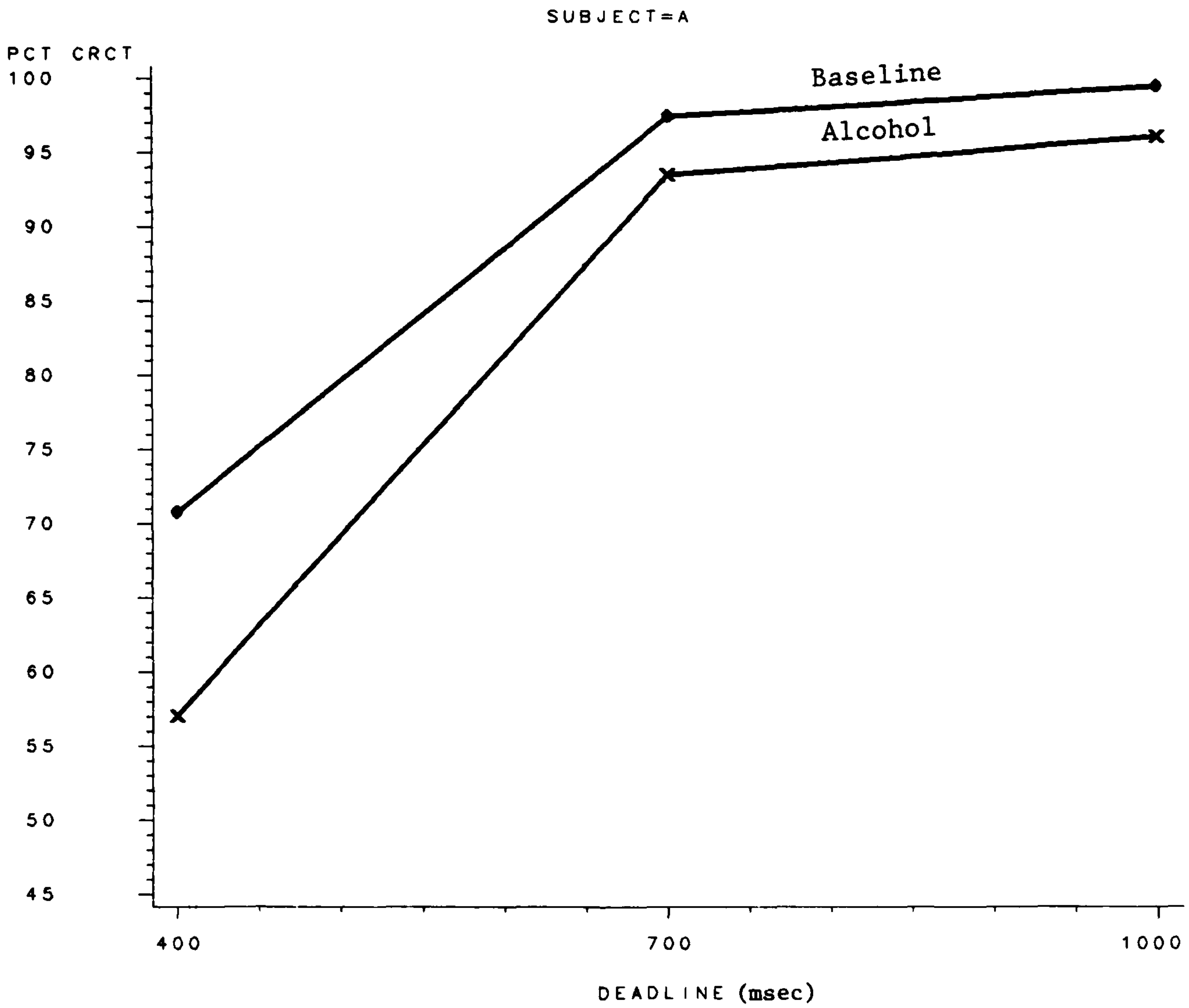


Figure 15. Accuracy vs. Deadline Condition - Subject A.

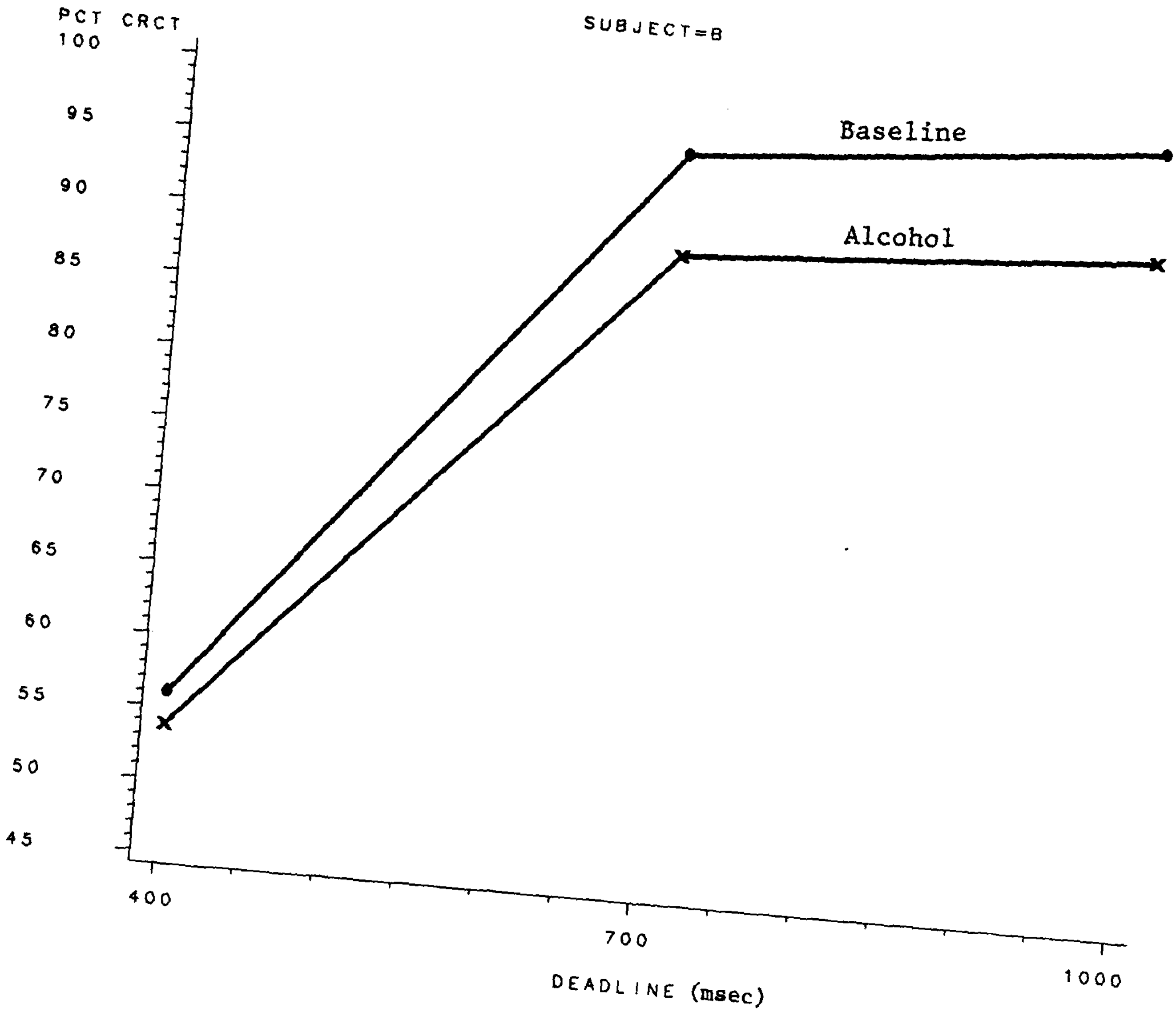


Figure 16. Accuracy vs. Deadline Condition - Subject B.

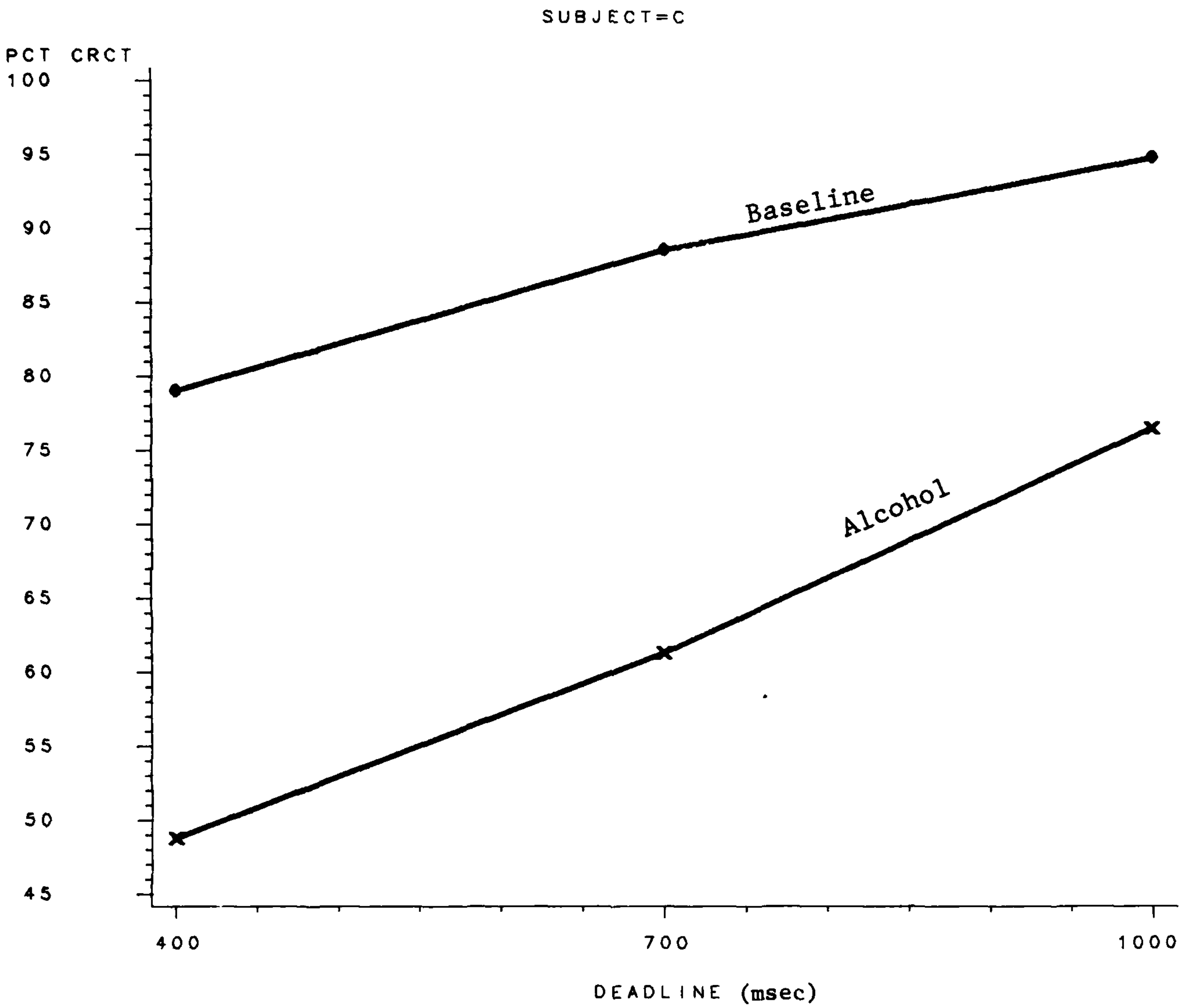


Figure 17. Accuracy vs. Deadline Condition - Subject C.

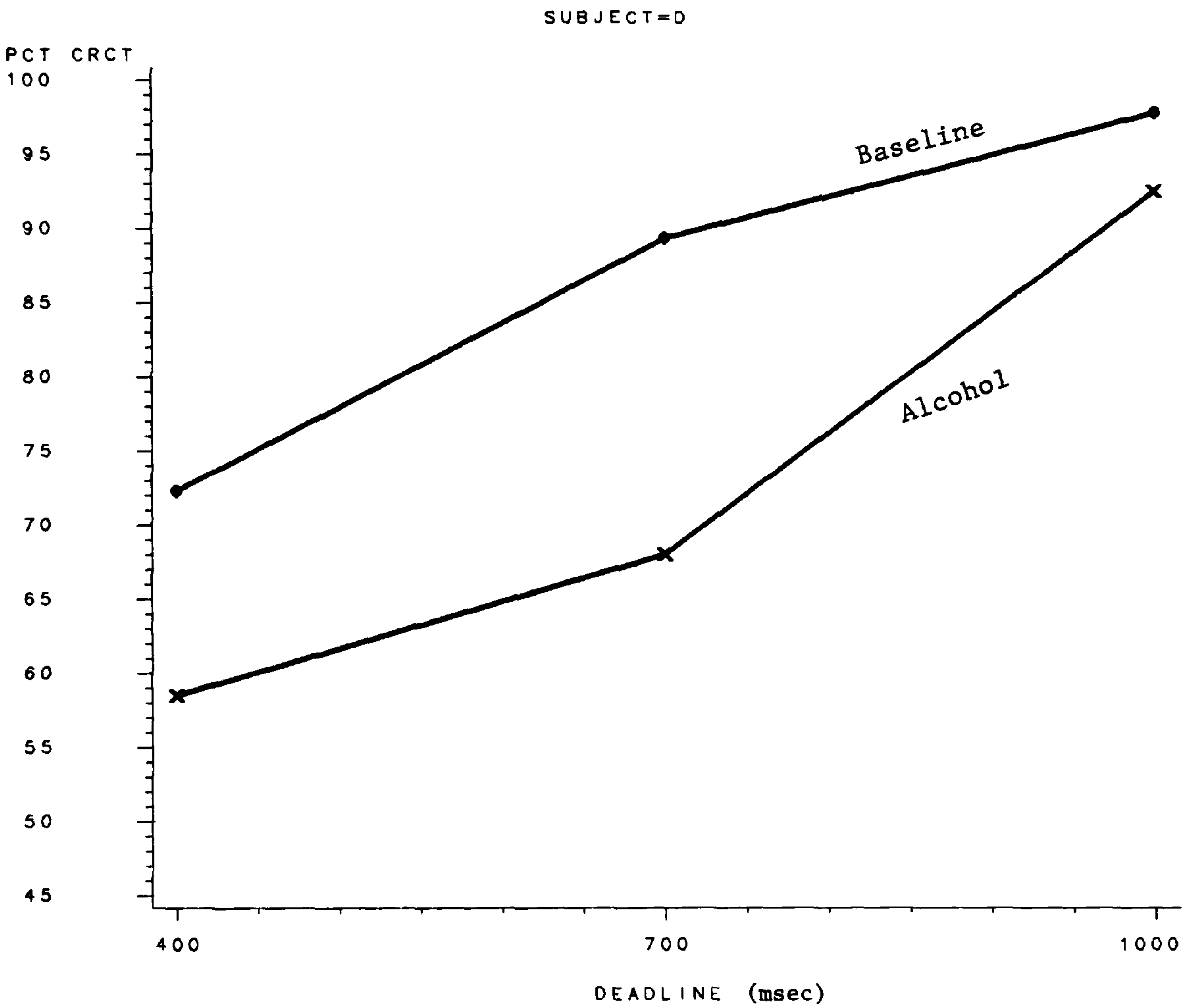


Figure 18. Accuracy vs. Deadline Condition - Subject D.

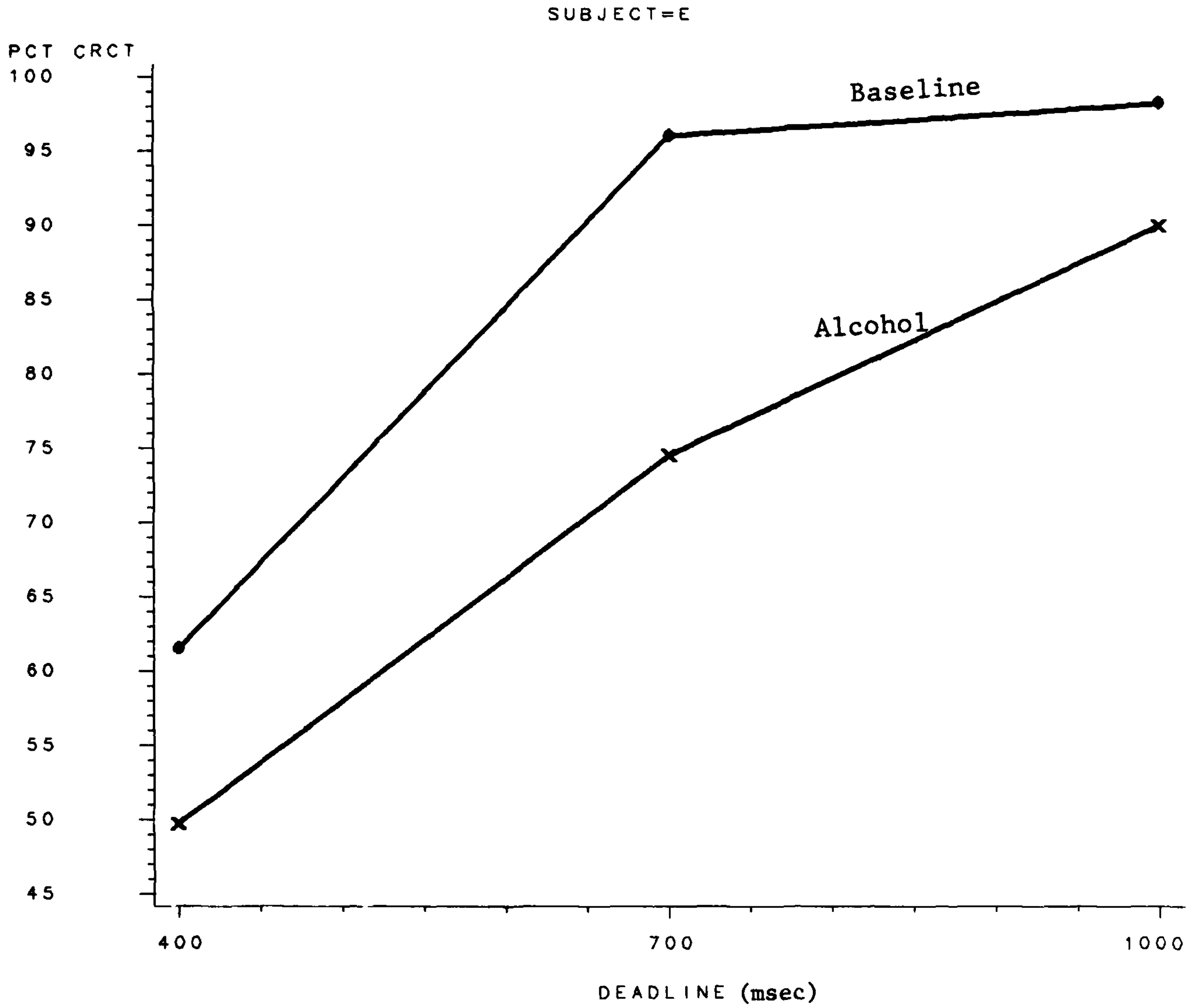


Figure 19. Accuracy vs. Deadline Condition - Subject E.

6.0 DISCUSSION

The objectives of the reported investigation were to evaluate performance differences attributable to specific visual characteristics of the Manikin Task (orientation, target shape and side of correct response) and to perform a preliminary analysis of the sensitivity of task performance to the administration of alcohol. The approach for assessing the sensitivity to alcohol relied upon the generation of speed-accuracy performance tradeoffs.

6.1 Manikin Figures and Training

During subject training, sufficient data was collected to perform a thorough analysis of Manikin figure characteristics. It was determined that orientation category significantly affected response time and accuracy on the task. The differences reflect a difference in the level of workload associated with the various orientations. These differences may be related to the number of mental rotations and the axes of rotation employed by the subject to orient the figure prior to discriminating right vs. left. This relationship should be further investigated using alternative spatial processing tasks requiring similar rotations.

An observation made by the experimenter was that subjects appeared to use one of two techniques in forming their responses, at least during the initial training. Some subjects exhibited a substantial amount of body movement in an attempt to "put themselves in the same orientation" as the Manikin on the CRT. Other subjects seemed to perform the rotation internally with a minimum amount of body movement. With training, the body movement became nonexistent as the subjects responded faster and had little time for any extraneous motions.

No significant performance changes were observed with respect to target shape and side of correct response. Although three subjects made faster right-side responses, overall the difference (40 msec) was not significant. This may have been due to the magnitude of the SIDE*SUBJECT interaction (used as the denominator in the F-test for SIDE) which may have masked the true left-right difference. A slight trend toward faster right-side responses may exist. However, the magnitude of the difference is slight. A small-scale follow-up study has failed to detect any difference in performance related to hand dominance.

With respect to training, subjects required seven or eight trials to achieve stable performance on the task. Response times decreased according to an exponential decay function with the learning rate for each subject estimated using least-squares regression. The percentage of correct responses was high even during the initial stages of training (94% to 97%). In addition, the percentage of missed responses exhibited a constant decline throughout training (from 3% down to 0.05%).

Although subjects continued to improve during the deadline training trials, the pattern of improvement was not uniform. For some subjects, a discrete decline in response time occurred possibly indicating a change in operator strategy or a different method of performing the task. It is quite possible that after extensive training under short deadline conditions, the structure of the task changes such that the mental processing involves more pattern recognition than spatial processing. This hypothesis could be investigated using a dual-task methodology simultaneously involving the

Manikin Task and either an alternative spatial processing task or a memory search/pattern matching task.

Throughout the study, large individual subject differences existed, resulting in a number of significant interactions with the subject variable. However, the high stability of the task over time was repeatedly verified by the consistency in performance rank order as a function of subject, orientation, target shape, and side of correct response. For example, the initial performance ordering by orientation (BE, FE, FI, BI) persisted through all seven trials.

6.2 Alcohol Stressor

The deadline procedures employed during the alcohol phase of the study produced the desired shift in response time and accuracy. Although the response times did not equal the deadlines, there were significant differences among the times for all three levels. For each deadline, there was no significant difference between the response times under baseline vs. alcohol. More importantly, the corresponding accuracies ranged from chance (49%) to near perfection (99%) across the various deadlines, a desirable feature for evaluating the speed-accuracy characteristics of a task under various stressors.

Significant declines in accuracy accompanied the administration of alcohol for all three deadline conditions. In general, the alcohol caused a downward shift on the accuracy axis of the speed-accuracy function. This reinforces the importance of not using a single criterion measure, such as response time, in evaluating information processing tasks.

From the results of this study, it is believed that further work in evaluating spatial processing ability under various stressors is warranted. Through the use of the Manikin Task and other spatial processing tasks, an investigation is needed of the mental rotation process when it involves three-dimensional rotation. Based on the differences observed for the various manikin orientations, it appears that there is a relationship between the type or amount of rotation required and the spatial processing performance measures.

In summary, the sensitivity of the Manikin Task to a specific CNS depressant stressor was confirmed by this investigation and its use is recommended in future studies of spatial processing ability.

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APPENDIX A

TRAINING DATA BY TRIAL NUMBER FOR EACH SUBJECT

Table A.1 --- Subject A.

	TRIAL						
	1	2	3	4	5	6	7
Response Time (msec)							
Overall Mean	1167	840	756	714	719	737	638
Standard Dev.	(248)	(193)	(176)	(158)	(110)	(103)	(90)
Mean Correct	1157	841	758	721	721	737	637
Mean Incorrect	1236	812	721	640	671	675	653
Accuracy							
% Correct	95.31	96.61	94.27	91.15	95.31	98.96	97.40
% Incorrect	3.91	3.39	5.73	8.85	4.69	1.04	2.60
% Missed	0.78	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX A (cont.)

Table A.2 --- Subject B.

	TRIAL						
	1	2	3	4	5	6	7
Response Time (msec)							
Overall Mean	1491	1291	1115	1080	1000	998	936
Standard Dev.	(339)	(335)	(292)	(279)	(250)	(241)	(212)
Mean Correct	1420	1257	1096	1069	995	994	934
Mean Incorrect	1510	1355	1103	1123	1085	1042	918
Accuracy							
% Correct	83.33	92.44	95.06	93.23	96.88	96.88	91.15
% Incorrect	5.21	3.39	2.86	5.99	2.86	2.86	8.59
% Missed	11.46	4.17	2.08	0.78	0.26	0.26	0.26

Table A.3 --- Subject C.

	TRIAL						
	1	2	3	4	5	6	7
Response Time (msec)							
Overall Mean	817	764	756	700	643	653	635
Standard Dev.	(184)	(167)	(146)	(139)	(108)	(135)	(118)
Mean Correct	817	765	758	701	644	655	635
Mean Incorrect	843	745	698	636	615	587	634
Accuracy							
% Correct	97.92	98.44	97.66	97.92	97.66	97.40	97.14
% Incorrect	2.08	1.56	2.34	2.08	2.34	2.60	2.86
% Missed	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX A (cont.)

Table A.4 --- Subject D.

	TRIAL						
	1	2	3	4	5	6	7
Response Time (msec)							
Overall Mean	1233	1039	962	992	944	804	773
Standard Dev.	(282)	(204)	(220)	(189)	(185)	(185)	(143)
Mean Correct	1211	1030	960	990	940	803	775
Mean Incorrect	1361	1080	842	1000	1450	742	675
Accuracy							
% Correct	95.31	97.66	96.88	98.44	99.48	95.83	97.92
% Incorrect	2.34	1.56	2.60	1.30	0.26	3.91	2.08
% Missed	2.34	0.78	0.52	0.26	0.26	0.26	0.00

Table A.5 --- Subject E.

	TRIAL						
	1	2	3	4	5	6	7
Response Time (msec)							
Overall Mean	1038	855	826	772	787	745	740
Standard Dev.	(221)	(146)	(128)	(105)	(124)	(109)	(105)
Mean Correct	1031	853	825	772	787	745	740
Mean Incorrect	1357	1600	1033	800	.	692	.
Accuracy							
% Correct	98.44	99.74	99.74	99.74	100.0	99.48	100.0
% Incorrect	1.30	0.26	0.26	0.26	0.00	0.52	0.00
% Missed	0.26	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX B

BASELINE AND ALCOHOL DATA BY PERIOD
FOR EACH SUBJECT

MANIKIN TASK DATA ANALYSIS

SUBJECT=A

OBS	ALCOHOL	DEADLINE	PERIOD	ACCURACY	REACTIME
1	A	400	1	57.29	0.513
2	A	400	2	60.42	0.537
3	A	400	3	57.29	0.540
4	A	400	4	53.13	0.541
5	NA	400	1	73.00	0.517
6	NA	400	2	61.00	0.519
7	NA	400	3	75.00	0.512
8	NA	400	4	74.00	0.527
9	A	700	1	90.63	0.637
10	A	700	2	93.75	0.638
11	A	700	3	92.71	0.630
12	A	700	4	96.88	0.615
13	NA	700	1	95.83	0.602
14	NA	700	2	95.00	0.604
15	NA	700	3	100.00	0.599
16	NA	700	4	99.00	0.600
17	A	1000	1	92.71	0.747
18	A	1000	2	95.83	0.725
19	A	1000	3	97.92	0.714
20	A	1000	4	97.92	0.706
21	NA	1000	1	99.00	0.644
22	NA	1000	2	100.00	0.654
23	NA	1000	3	99.00	0.654
24	NA	1000	4	100.00	0.669

SUBJECT=B

OBS	ALCOHOL	DEADLINE	PERIOD	ACCURACY	REACTIME
25	A	400	1	54	0.431
26	A	400	2	47	0.407
27	A	400	3	59	0.406
28	A	400	4	55	0.449
29	NA	400	1	55	0.405
30	NA	400	2	59	0.390
31	NA	400	3	57	0.378
32	NA	400	4	53	0.358
33	A	700	1	92	0.550
34	A	700	2	90	0.550
35	A	700	3	89	0.555
36	A	700	3	84	0.528
37	NA	700	1	95	0.534
38	NA	700	2	96	0.528
39	NA	700	3	95	0.529
40	NA	700	4	97	0.539
41	A	1000	1	91	0.555
42	A	1000	2	90	0.551
43	A	1000	3	92	0.565
44	A	1000	4	91	0.553
45	NA	1000	1	98	0.543
46	NA	1000	2	100	0.540
47	NA	1000	3	98	0.537
48	NA	1000	4	98	0.540

MANIKIN TASK DATA ANALYSIS

------------------------------------ SELECT=C ------------------------------------

OBS	ALCOHOL	DEADLINE	PERIOD	ACCURACY	REACTIME
49	A	400	1	45	0.640
50	A	400	2	49	0.726
51	A	400	3	52	0.682
52	A	400	4	45	0.738
53	NA	400	1	73	0.639
54	NA	400	2	80	0.661
55	NA	400	3	82	0.650
56	NA	400	4	81	0.664
57	A	700	1	61	0.603
58	A	700	2	55	0.644
59	A	700	3	71	0.692
60	A	700	4	58	0.700
61	NA	700	1	91	0.699
62	NA	700	2	88	0.664
63	NA	700	3	86	0.690
64	NA	700	4	89	0.700
65	A	1000	1	80	0.807
66	A	1000	2	84	0.787
67	A	1000	3	79	0.770
68	A	1000	4	67	0.730
69	NA	1000	1	95	0.747
70	NA	1000	2	93	0.723
71	NA	1000	3	96	0.738
72	NA	1000	4	95	0.763

------------------------------------ SELECT=D ------------------------------------

OBS	ALCOHOL	DEADLINE	PERIOD	ACCURACY	REACTIME
73	A	400	1	45	0.516
74	A	400	2	58	0.585
75	A	400	3	63	0.679
76	A	400	4	68	0.628
77	NA	400	1	59	0.473
78	NA	400	2	80	0.580
79	NA	400	3	69	0.577
80	NA	400	4	81	0.586
81	A	700	1	75	0.573
82	A	700	2	83	0.676
83	A	700	3	55	0.535
84	A	700	4	59	0.459
85	NA	700	1	90	0.623
86	NA	700	2	92	0.626
87	NA	700	3	86	0.635
88	NA	700	4	89	0.633
89	A	1000	1	85	0.749
90	A	1000	2	94	0.775
91	A	1000	3	97	0.771
92	A	1000	4	94	0.754
93	NA	1000	1	100	0.718
94	NA	1000	2	100	0.736
95	NA	1000	3	93	0.656
96	NA	1000	4	98	0.745

MANIKIN TASK DATA ANALYSIS

---------------------------------- SUBJECT=E ----------------------------------

OBS	ALCOHOL	DEADLINE	PERIOD	ACCURACY	REACTIME
97	A	400	1	54	0.311
98	A	400	2	52	0.349
99	A	400	3	49	0.303
100	A	400	4	44	0.356
101	NA	400	1	78	0.516
102	NA	400	2	58	0.438
103	NA	400	3	54	0.393
104	NA	400	4	56	0.378
105	A	700	1	82	0.597
106	A	700	2	65	0.610
107	A	700	3	80	0.599
108	A	700	4	71	0.578
109	NA	700	1	95	0.569
110	NA	700	2	97	0.590
111	NA	700	3	96	0.574
112	NA	700	4	96	0.569
113	A	1000	1	86	0.636
114	A	1000	2	92	0.649
115	A	1000	3	85	0.667
116	A	1000	4	93	0.640
117	NA	1000	1	97	0.619
118	NA	1000	2	95	0.625
119	NA	1000	3	98	0.597
120	NA	1000	4	99	0.589

END

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